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National Assessment of the Urban Particulate Problem. Volume II Particle Characterization

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This document is one volume of a 16-volume report presenting an overall assessment of the particulate problem, which was conducted by GCA/Technology Division for EPA. This particular document presents the results of analyses that were undertaken in an effort to characterize the various components and types of particles that comprise ambient suspended particulate matter. Most of this information was obtained by optical microscopic analysis of filter segments. A quality control program in the form of blind replicate analysis was utilized and a statistical analysis of the results is also reported in this volume. This and the 14 city reports are viewed primarily as repositories of data and provide documentation and background information for Volume I of the study - National Assessment of the Particulate Problem - Final Report.

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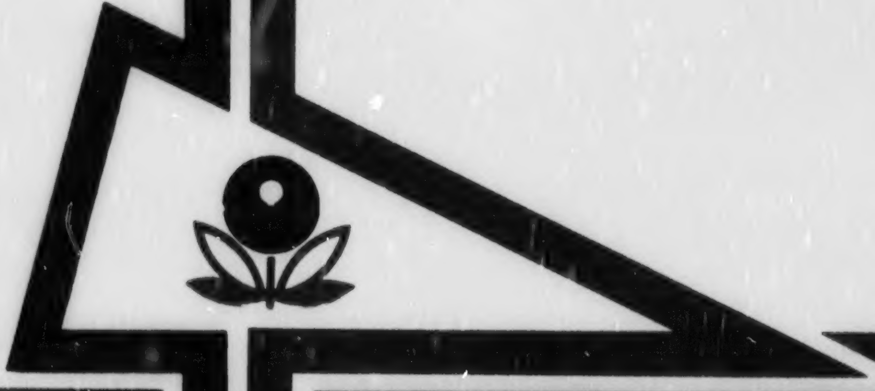
VOLUME II

PARTICLE CHARACTERIZATION



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NATIONAL ASSESSMENT OF THE URBAN PARTICULATE PROBLEM

VOLUME II

PARTICLE CHARACTERIZATION

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Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

July 1976

FOREWORD

This document is one volume of a 16-volume report presenting an overall assessment of the particulate problem, which was conducted by GCA/Technology Division for EPA.

This particular document presents the results of analyses that were undertaken in an effort to characterize the various components and types of particles that comprise ambient suspended particulate matter. Most of this information was obtained by optical microscopic analysis of filter segments. A quality control program in the form of blind replicate analysis was utilized and a statistical analysis of the results is also reported in this volume.

The chemical and physical analyses reported herein were included in the program to complement the conclusions derived from other, independent types of analyses utilized throughout this study. The working summaries of these other studies are contained in Volumes III through XVI which cover the 14 urban areas. This and the 14 city reports are viewed primarily as repositories of data and provide documentation and background information for Volume I of the study — National Assessment of the Particulate Problem — Final Report. Volume I should be considered the principal output of the study.

The 16 volumes comprising the overall report are as follows:

Volume I — National Assessment
Volume II — Particle Characterization

Volume III – Denver
Volume IV – Birmingham
Volume V – Baltimore
Volume VI – Philadelphia
Volume VII – Washington
Volume VIII – Chattanooga
Volume IX – Oklahoma City
Volume X – Seattle
Volume XI – Cincinnati
Volume XII – Cleveland
Volume XIII – San Francisco
Volume XIV – Miami
Volume XV – St. Louis
Volume XVI – Providence

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SECTION I

INTRODUCTION

This volume presents data concerning the physical and chemical properties of the particulate matter collected on selected hi-vol filters obtained from existing filter banks for each of the 14 study cities. Most of this information was obtained as part of this contractual effort via optical microscopic analysis of 445 samples of hi-vol filters. The microscopy was performed by two analytical laboratories: 400 hi-vol filter samples were analyzed by Water C. McCrone Associates, Inc. (Laboratory 1), and 45 hi-vol filter samples were analyzed by Eastern Analytical Laboratories, Inc. (Laboratory 2). As part of the quality control procedures, each of the 45 samples analyzed by Laboratory 2 were cut from filters from which samples were also analyzed by Laboratory 1. In addition, all samples submitted were identified only by a randomly generated five digit number. The analysts had no information concerning the geographic location, time of year, or nature of the area in which the sample had been collected. In addition, replicate samples from some filters were resubmitted to both laboratories with new identification so as to appear as normal submittals. Since both laboratories utilized more than one analyst, these procedures resulted in as many as four microscopists observing samples from the same filter and, in some cases, the same analyst examining replicate samples from the same filter as many as three times. The results of statistical evaluations of these several quality control procedures are presented so that, perhaps for the first time, some quantitative level of significance can be ascribed to the results of optical microscopy as an analytical method for hi-vol filter analysis in general, and, more specifically, the degree to which this type of analysis supported or refuted the conclusions derived from other, independent types of analysis utilized throughout this study.

In addition to the routine optical microscopic analyses, Laboratory 1 was asked to perform some special analytical tasks in an effort to obtain even greater detail of the particulate. These tasks included the following:

- Detailed physical examination of 15 hi-vol filter samples
- Chemical analysis of 8 hi-vol filter samples
- Particle size distributions as a function of particle type for 4 hi-vol filter samples.

EPA's Environmental Monitoring and Support Laboratories (EMSL) analyzed samples from some of the filters that underwent microscopic examination. This included analyses for 13 metals as well as for ammonium, nitrate, and sulfate ions. Another EPA group, the Aerosol Research Branch (ARB) of the Environmental Sciences Research Laboratory, conducted research programs in two of the study cities as part of their own air pollution research and development activities. Much of this data, which included wind direction-specific TSP monitoring, particle sizing, and elemental analysis as a function of wind direction and particle size, were made available to the GCA/Technology Division study team. The data generated by EMSL and some of that provided by ARB are summarized in this volume. In addition, some of the local agencies in the study cities provided the results of their routine analytical activities and much of those data are also summarized.

The data in this volume are presented in much the same way in which the study was conducted; that is, on a city-by-city basis. The summary results for each city are organized around the following common items:

- A map showing the sampling site locations
- A table giving the sampling site descriptions

- A table summarizing the meteorological observations for the days of interest
- A table showing the results of microscopic analyses for the selected filters
- A table showing the composite summary results of microscopic analyses for each site
- A table showing the results of replicate microscopic analyses
- A table showing the composite summary results of microscopic analyses for all sites combined.

These data are supplemented with any additional information available for a particular city and a discussion of the key results or conclusions for each city.

In order to give the reader a better understanding of this portion of the study, and to present data which should give guidance as how to best interpret the results and insight into its overall significance, several facets of the filter analysis program are discussed prior to the presentation of the summary results for the 14 cities. These include a brief description of the experimental design as far as the selection of the sites to be studied, as well as the rationale for selecting particular days at each site. In some cities a study of the trends in the types and amounts of TSP was conducted, and this portion of the program is also briefly discussed. Probably the single most important product of the filter analysis portion of the study, however, is the information gleaned from the quality control effort. Therefore, the basic purpose and design of that effort, as well as the results and statistical analyses of results, precede the city summary results section. It is hoped that this organization of the data will allow for maximum utilization of the analytical results, along with an understanding of the underlying precautions that must be considered in applying them.

SECTION II

ANALYTICAL METHODS

Several laboratories contributed to the particulate characterization portion of this study at various levels of effort. Optical microscopy was intended as the primary analytical method with a limited num[illegible] of chemical analyses and sophisticated instrumental techniques to be employed for supporting information. Two analytical laboratories did the microscopy under contract, with Walter C. McCrone Associates, Inc. being responsible for the analyses of 400 filters and Eastern Analytical Laboratories, Inc. for the analyses of 45 filters. Two EPA groups generated chemical and/or physical data concerning particulate characterization that was of importance to the present program. In addition, some local agencies in the study areas provided the results of their routine analytical activities. The analytical techniques utilized by each of these several contributors is summarized, insofar as possible, to enable the reader to understand the types of procedures and the variability that may have existed. No attempt has been made to evaluate the analytical methods as that was beyond the scope of the present program.

ACQUISITION, HANDLING AND SUBMITTAL OF FILTERS FOR ANALYSIS

Members of the GCA study team acquired filters directly from the cognizant agencies while conducting each city visit. Although there was a general understanding of the sites and dates of interest prior to the city visits, the final selection of study sites was not made until after conferring with the local authorities. Generally, more filters were selected than could ultimately be analyzed so that there would be maximum flexibility in selecting the exact sampling days to be examined.

All filters that were obtained from the control agencies were returned to a clean room at GCA/Technology Division. Each filter that was considered for microscopic analysis was examined visually for tears, pinholes, rain splatter, and improper installation in the hi-vol as indicated by a nonuniform border. Those filters that were acceptable for analysis were assigned a randomly generated five digit number. A 3/4-inch by 8-inch strip was removed from the filter, the identifying number affixed to the margin, and the sample folded on itself and sealed in a small glassine envelope. The appropriate identification number was also printed on the outside of the envelope. Records and cross references identifying each sample with the associated city, site, date, and TSP loading were maintained in triplicate by GCA.

In the case of Laboratory 1, samples were submitted in groups of 26 and transmitted by registered air mail with return receipts. Samples, usually in batches of three, were hand carried to Laboratory 2 because of its proximity to GCA/Technology Division.

LABORATORY 1

Particles on the hi-vol filter samples were removed with a tungsten needle which carried a drop of slightly warm and semi-sticky Aroclor^{R} 5442 (refractive index - 1.662) at the tip. The drop of Aroclor containing the particles from the filter was then transferred to a glass slide and covered with a coverslip. This task was not performed by the microscopists but rather by specially trained personnel working in a clean room.

The principal instrument used for the routine analysis of the filters was the polarizing microscope. Particles were examined with both transmitted and reflected light and characterized as to their generic type by observing morphology, transparency, color, and other physical properties. The microscopists then used their knowledge, experience, and suitable reference standards to specify the particle types. The size and number of each type of observed particle were tallied so that the mass percent for each category could be calculated using either assumed or measured densities. Each category of particles that comprised more than 5 percent of the collected mass was also classified as to the range (maximum and minimum) of particle sizes and the average size in that category.

Fifteen of the four hundred filter segments thus analyzed were designated for detailed physical examination by microscopic and physical techniques so as to constitute a more exclusive filter analysis to such degree of detail as to assure the ultimate achievable level of confidence in the particle characterization. Techniques typically utilized for this detailed examination included dispersion staining, electron microprobe analyses, x-ray diffraction, scanning electron microscopy, and energy dispersive x-ray analyses.

Laboratory 1 was also asked to perform some detailed particle sizing and some chemical analyses. The particle sizing was done for specific particle types using conventional particle counting techniques. The size intervals that were used during this program were: < 1 μm, 1 μm - 5 μm, 5 μm - 10 μm, 10 μm - 20 μm, 20 μm - 50 μm, and largest observed particle size. The chemical analyses task included benzene solubles, organic carbon, inorganic carbon, and total carbon. The benzene soluble fraction was determined by treating a preweighed portion of filter with benzene, evaporating the solvent, and reweighing the filter. The inorganic carbon determination involved placing the benzene soluble-free sample into a small chamber and adding hydrochloric acid solution to hydrolyze carbonates. The carbon dioxide thus released was swept from the chamber with pure nitrogen gas and bubbled through a barium hydroxide solution to form a barium carbonate precipitate. The precipitated barium carbonate was separated by centrifugation, dried, and mixed with a known amount of potassium bromide. This mixture was then pressed into a pellet, and the barium carbonate fraction determined with infrared absorption spectrophotometry. The organic carbon content was determined by conventional, Pregl-Dumas type combustion analyses and the organic and inorganic carbon fractions were summed to give the total carbon content.

LABORATORY 2

Laboratory 2 made four mounts from each filter. Three of those were dry mounts; that is, the particles were transferred without the use of a mounting medium; and one wet mount was made using immersion oil (refractive index - 1.660). The microscopists at this laboratory prepared their own mounts.

As was the case with the other microscopy contractor, Laboratory 2 relied heavily on the polarizing microscope as the analytical tool of choice. Particles were examined with both transmitted and reflected light and characterized as to their generic type by observing morphology, transparency, color, and other physical properties. This laboratory, however, utilized scanning electron microscopy and photomicroscopy frequently for the routine examination of hi-vol samples. Again, the size and number of each type of observed particle were tallied so that the mass percent for each category could be calculated using either assumed or measured densities. The range of particle sizes and the average particle size for each category of particles was also reported as noted above.

ENVIRONMENTAL MONITORING AND SUPPORT LABORATORIES (EMSL)

This section of EPA which, among other duties, is responsible for the routine analysis of all the National Aerometric Sampling Network samples, volunteered to analyze hi-vol filter samples that were selected for microscopic examination. In keeping with its own well established quality assurance policies, however, only filters which were accompanied by an unexposed blank filter traceable to the same batch would be accepted for analysis. Most agencies do not follow such rigid procedures, so that the total number of filters that were ultimately submitted to, and analyzed by, EMSL was 51. Each of the filters was subjected to the routine NASN analytical procedures and included the following analyses:

- Ammonium ion by the sodium hypochlorite method
- Nitrate ion by the N-(1-naphthyl)ethylenediamine method
- Sulfate ion by the methylthymol blue method
- Thirteen metals (vanadium, lead, titanium, beryllium, tin, arsenic, cadmium, chromium, cobalt, copper, iron, manganese, and nickel) by quantitative optical emission spectrography.

AEROSOL RESEARCH BRANCH (ARB)

This section of EPA conducted special ambient air sampling programs in two of the study cities. These studies, which were performed in Miami during June 1975 and in St. Louis during July 1975, included both conventional and novel sampling and analysis procedures. Daily TSP levels were monitored with conventional hi-vols while special instrumentation allowed determination of 18 metals at 2-hour intervals, the size distribution of particulates as a function of wind direction, and the corresponding elemental composition of the size fractionated samples.

A novel sampling device, known as the streaker,[1] allowed collection of particulate material for subsequent determination of 18 metals with a 2-hour time resolution. This device draws an air sample at a rate of 2 liters per minute through a strip of Nuclepore filter. The sampling head moves at a rate of 2 millimeters per hour which allows the collection of particulate matter for several days of unattended operation. The Nuclepore strip can then be removed for elemental determination of the particulate by proton-induced x-ray emission analysis.[2] This technique is useful for determining the following 18 elements: aluminum, silicon, phosphorus, sulfur, carbon, potassium, calcium, titanium, vanadium, chromium, manganese, iron, nickel, copper, zinc, bromine, strontium, and lead. The use of this powerful analytical technique, combined with the short time resolution of the sampling device, greatly facilitates correlation of the chemical properties of particulate with meteorological parameters.

The ARB studies also included cascade impactors that were controlled by a wind direction sensor. Up to four impactors were operated such that each was operating only when the wind was from a desired direction. For example, each of four impactors could be run only when the wind was from a particular 90 degree sector so that the particle size distribution as a function of the four selected wind directions could be determined. The impactors utilized were low flow rate instruments so that long sampling times (e.g., 1 week) were required. The particulate collected on the impactor stages was also subjected to proton-induced x-ray emission analysis, indicating the elemental composition as a function of particle size.

LOCAL AGENCY ROUTINE ANALYSIS

Several of the local agencies that were visited perform routine chemical analyses on all or some of the collected hi-vol filters. Although only portions of the data are presented in summary form, a brief description of the analytical methods is warranted. Filters from Baltimore are analyzed by the Maryland Bureau of Air Quality Control. The concentration of lead is determined by atomic absorption spectrophotometry after low temperature ashing and nitric acid digestion. Benzo(a)pyrene is determined by spectrophotofluorometry after separation by their layer chromatography.

The Air Management Services Laboratory in Philadelphia analyzes for several metals by atomic absorption spectrophotometry after nitric acid digestion. Sulfate is determined gravimetrically by precipitation of barium sulfate with barium chloride. The Oklahoma City-County Health Department, Environmental Health Services, Division of Air Quality Control, runs monthly composited analyses for some metals, including lead, at each monitoring site. They also utilize atomic absorption spectrophotometry following a nitric acid digestion.

Filters from the San Francisco area are analyzed by the Bay Area Air Pollution Control District. Although regular glass fiber filters are used to report TSP levels, cellulose filters are utilized for sampling particulate matter for subsequent chemical analyses because of their chemical purity. A portion of each filter is ashed at low temperature, extracted with nitric acid and the metals content determined by atomic absorption. Another portion of the filter is extracted with water and then analyzed for four species. Ammonium ion is determined by specific in electrode, sulfate by the barium chloride turbidimetric procedure, nitrate by first reducing to nitrite with cadmium and then colorimetric analysis by the Griess reaction, and chloride by the turbidimetric silver nitrate procedure.

SECTION III

EXPERIMENTAL DESIGN

FILTER SELECTION CRITERIA

The most recent year of record for air quality data at the initiation of this study was 1974 and, thus, the major thrust of the microscopic analysis effort was directed at that most currently available set of samples. Within each study area the selection of samples was normally limited to filters from the 3 months of 1974 with the highest observed TSP levels and the 3 months of 1974 with the lowest observed TSP levels. In this way, it was hoped that significant differences in the types of particles identified on the filters, if they existed, could help in identifying the source(s) responsible for the differences in TSP levels.

Whenever possible, three sites were chosen as typical of the study area, and these sites composed the core for the selection of filter samples. The sites selected usually typified a central business district location, an industrial location, and a residential area. Obviously it was impossible to strictly adhere to these guidelines in each city and, further, the site classification for one study city did not necessarily correspond particularly well with that of another city. However, insofar as possible, this common thread was sewn into the site selection process. Several "wild card" sites were also chosen for study because of special circumstances or influences. Sites of this type included those very near major highways, some sites particularly close to troublesome sources, some sites that appeared not to be influenced by identifiable sources, and, when possible, sites at or near the same location but at different heights.

Six filters were usually selected for examination at each of the three core sites. Three of these were from the 3 months of 1974 with the highest TSP levels and three filters were from the 3 months of 1974 with the lowest TSP levels, as described previously. Within each 3-month group, one filter was selected that recorded a high particulate loading, one filter was selected that recorded a loading near the mean from that group of samples, and a third filter was selected that was intermediate between the high and mean levels. It was hoped that in this way the examination of filters representative of several different TSP loadings would indicate if a significant change in the type of particulate material accompanied changes in the particulate loadings.

The TSP data for each study area were analyzed to determine if the observations at all sties in general, and the three core study sites in particular, followed the same trends. That is, did the sites tend to record high (and low) values on the same day or did some of the sites experience particulate burdens atypical of the rest of the area on any particular day.

In most cases, the TSP levels at the sites did follow a similar trend, and an "area wide" approach was followed in which the filters were selected for the same day at the three sites. There were cases, however, in which a "site" approach was followed where the filters were selected for their suitability for meeting the criteria at each site regardless of the sample day. This was particularly true in the case of "wild card" sites, and occasionally in cities where filters were missing or consumed in prior analyses, so that the "area wide" approach was impracticable.

In three of the study cities, samples from filters collected prior to 1974 were obtained for microscopic analysis to see if any trend in particulate types could be observed. The sites selected for this special analysis were from the NASN since the filters were known to have been properly preserved in the EPA filter bank. Time and fiscal constraints limited this effort to only three or four filter analyses for each year of interest. Filters selected for each year were representative of a high TSP level at that site for that year, an observation near the mean for the year, and an intermediate observation between the mean and high levels.

It was explicitly understood by both microscopy subcontractors that as complete objectivity as possible was a key component of the experimental design. As described in Section II, this meant that a randomly generated number was the only piece of information available for each filter sample. Absolutely no information concerning the city, site, TSP loading, etc. could be obtained by the analysts. Furthermore, the blind submittal of samples was vital to the successful execution of the replicate analysis portion of the experiment.

Initially, the replicate analysis task was designed to include only the examination by Laboratory 2 of 45 filters previously analyzed by Laboratory 1. Early in the program, however, it became evident that the resubmittal of filter samples to the same laboratory would be a meaningful experiment. Since more than one analyst was involved in each laboratory, and since there was no control over the assignment of samples to analysts, it was impossible to precisely design this portion of the program. All that was known was that the resubmittal of samples would result in either inter- or intra-analyst comparisons. Further, since there was no control over the choice of analysts for any particular sample, it was impossible to determine the number of such submittals required to achieve statistically significant levels of confidence in the results. Recognizing these limitations, while at the same time understanding the potential for greatly increasing the usefulness of the data, 48 of the 400 total samples submitted to Laboratory 1 were replicate submissions.

SECTION IV

QUALITY CONTROL

As mentioned in Section II, each filter was assigned a randomly generated five-digit number which served as the only identifier for the filter sample so that each analyst had no information concerning the city, site, TSP loading or probable local sources associated with the sample. Furthermore, the use of two laboratories for the microscopy, coupled with the randomly generated identifying numbers, permitted a fairly comprehensive quality control program in the form of blind replicate analyses. Since both laboratories utilized more than one analyst, these procedures resulted in as many as four microscopists observing samples from the same filter and, in some cases, the same analyst examining replicate samples from the same filter as many as three times.

Table 1 shows the weight percentage of the four major constituents for each pair of analysts that examined samples from the same filter. Table 2 summarizes the differences between results reported by different analysts and by the same analyst when examining samples from the same filter for minerals and combustion products, the two classes of particles which together typically account for about 90 percent of the filter loadings. Table 2 shows some very large average differences in the results reported, both by different analysts and by the same analyst. It appears, however, that the results of replicate analyses by a single analyst are more consistent than comparisons between analysts. Analysts A, B and C were from one laboratory and analysts D and E from the other laboratory. Analyst D, who consistently differed substantially from the other analysts, was used very little during the program.

Table 3 presents statistical summaries of comparisons of microscopists again for two categories, minerals and combustion products. It is apparent from the means that some very sizable differences occur in the general run of two analysts' results. To provide some quantitative perspective, a simple t-test was made on the matched data from each pair of analysts. (The calculated Student's t-value presented in Table 3 was calculated in such a way as to take account of the matched-pair nature of the data, so that the variability of the various filters does not inflate the t-value.) Table 4 presents the significance probabilities associated with the t-tests, and the verbal description of the meaning that we would attach to each probability. Although the assumptions underlying the t-test are not strictly met by this data, the results of the comparisons are sufficiently clear-cut that we have no important concern on that matter. Only three of the eight pairs for minerals (AB, CD, CE) and two for combustion products (AB, CD) exhibit sufficient consistency such that one can reasonably attribute the difference to chance. Additionally, two of the five pairs that do show agreement had only two comparisons so the ability to illustrate disagreement is limited.

Table 5 presents the data for those samples analyzed by more than two analysts and Table 6 summarizes the intra-analyst comparisons for the three microscopists that examined replicate samples from the same filter. In general the intra-analyst results were more consistent than were the comparisons between two analysts, but there were some distressingly large differences.

Given the inconsistencies documented above, it was decided to look at the more detailed components of the microscopy results for one pair of analysts to see whether any ready explanation could be found for some of the inconsistency. Table 7 presents the results of this detailed analysis, involving analysts B and C. Though this one case can by no means be presented as being conclusive, it does bring up certain curiosities. Looking at the data in Table 7, it is indicated that analyst B had, on the average, higher mineral readings than analyst C. Analyst C had higher readings for combustion products, and to a lesser extent biologicals, than did analyst B.

The major contribution to these differences were calcite and quartz for minerals and incinerator fly ash for combustion products.

The microscopists that were involved in the analyses were asked to comment on the results of the quality control program. The analysts identified three problem areas: misidentification, misassignment and fatigue. Although they did not consider misidentification to be much of a problem in this program, it was felt that additional training and standardized procedures would help.

Misassignment may be more of a problem in that different microscopists may identify a particle correctly but assign it to different categories. For example, coal fly ash often has substantial amounts of quartz, limestone and other minerals and may be classified as combustion product by one analyst and as mineral by another. Again a consistent set of guidelines would be of great value. Fatigue, especially when faced with the prospect that when finished with the present sample there are many more waiting to be done, was frequently noted by the microscopists. The problem is aggravated when conversions into weight percents must be made. One recommendation was that no more than three or four samples be done at one sitting and, when counting and converting becomes tedious, the analyst should stop for the day.

Table 1a. COMPARISONS OF MICROSCOPISTS

Minerals (percentage by weight)

A	B	A	C	A	D	A	E	B	C	B	D	B	E	C	D	C	E	D	E
48	56	63	50	10	7	77	23	74	32	None		74	45	46	5	32	45	5	66
21	82	10	31	65	5	21	42	69	40			74	39	14	5	48	25		
96	96	87	46	83	6	6	22	74	24			93	49			24	39		
82	86	31	22	87	5	75	26	63	30			84	11			31	31		
66	78	68	10	92	10	66	50	75	39			88	35			50	45		
75	77	48	32	80	5	75	26	91	40			78	50			31	39		
78	65	76	53			63	45	69	30			77	26			29	39		
70	66	27	28			50	39	84	56			63	12			46	66		
68	68	80	16			59	64					99	36			30	39		
78	89	69	23			10	39					84	31			50	53		
91	79					87	66					93	47			39	30		
86	93					89	30					63	39			31	27		
77	78					91	25					75	30			56	23		
30	74					80	9					84	23						
						86	47					96	57						
												39	28						
												49	15						
												74	48						

Combustion products (percentage by weight)

A	B	A	C	A	D	A	E	B	C	B	D	B	E	C	D	C	E	D	E
51	42	27	28	89	47	21	77	16	23	None		16	52	26	95	23	52	95	27
78	17	85	68	32	95	79	58	30	48			16	61	49	95	30	74		
0	4	8	26	13	94	84	78	16	34			7	51			34	61		
6	16	60	55	8	95	19	74	28	50			16	89			53	66		
20	10	10	50	4	90	20	48	5	41			11	63			28	55		
15	15	15	37	18	95	15	73	5	36			10	48			68	58		
12	9	8	36			27	55	21	62			15	73			60	51		
15	26	42	40			40	60	6	29			32	48			26	27		
4	12	18	49			36	35					1	64			50	61		
1	7	18	38			85	58					10	53			27	47		
8	16					8	27					7	39			41	70		
10	7					6	70					28	61			27	72		
21	17					3	75					3	70			29	77		
89	25					10	91					8	77						
						10	39					4	43						
												14	36						
												49	86						
												24	52						

Table 1b. COMPARISONS OF MICROSCOPISTS

Biologicals (percentage by weight																			
A	B	A	C	A	D	A	E	B	C	B	D	B	E	C	D	C	E	D	E
1	0	0	0	1	46	1	7	5	4	None		0	0	3	0	3	7	0	7
1	0	0	1	0	0	0	0	0	0			0	16	12	0	4	0		
0	0	1	3	0	0	1	0	0	3			0	14			3	0		
2	0	0	8	1	0	0	0	0	0			5	0			0	0		
11	6	1	5	1	0	1	14	0	0			0	0			2	1		
0	0	3	1	0	0	1	0	7	39			0	0			0	0		
4	1	0	1			0	0	0	8			0	0			39	3		
5	0	0	2			10	0	5	28			47	36			16	1		
0	0	0	12			5	0					1	1			28	0		
2	0	4	18			11	2					1	0			0	3		
0	0					0	1					7	3			0	0		
1	0					0	0					5	0			1	3		
0	0					0	1					0	0			0	9		
0	0					0	1					0	0						
						0	3					1	2						
												6	2						
												0	1						
												0	40						
Rubber (percentage by weight)																			
28	20	4	25	4	0	4	0	4	16	None		0	0	25	0	25	0	0	0
19	4	9	15	3	0	4	0	20	20			6	0	25	0	16	0		
0	5	21	35	2	0	4	0	4	21			0	0			20	0		
3	0	33	30	0	0	10	0	10	8			4	0			20	0		
0	5	16	10	0	0	3	0	10	15			20	0			40	0		
1	1	31	30	1	0	0	0	5	6			10	0			15	0		
0	2	2	25			0	0	1	4			0	0			6	0		
0	1	9	21			0	0	5	14			0	0			6	0		
4	0	2	2			0	0					1	0			14	0		
9	0	4	0			3	0					1	0			16	0		
3	6					9	0					5	0			2	0		
9	8					2	0					5	0			0	0		
3	25					9	0					0	0			10	0		
10	8					0	0					0	0						
						4	0					0	0						
												6	0						
												8	0						
												5	0						

Table 2. SUMMARY OF DISCREPANCIES IN DUPLICATE ANALYSES

Combustion products (below diagonal)

	Minerals (above diagonal)				
Analyst	A	B	C	D	E
A	56 (8) 18 (8)	21 (14)	69 (10)	149 (6)	77 (15)
B	75 (14)	25 (7) 13 (7)	71 (8)	–	79 (18)
C	66 (10)	94 (8)	– –	128 (2)	31 (13)
D	133 (6)	–	89 (2)	– –	172 (1)
E	92 (15)	124 (18)	50 (13)	111 (1)	48 (2) 49 (2)

Note: Each entry is the average difference between the results reported for pairs of repeated analyses of the same filter, expressed as the percentage of the mean of the two reported results in each case. The entries along the main diagonal summarize the replicate analyses by the same analyst, while those off the diagonal are averages of the comparisons between two analysts. The number of paired analyses in each comparison is given in parentheses.

Table 3. **COMPARISONS OF MICROSCOPISTS: MINERALS AND COMBUSTION PRODUCTS**

	A	B	A	C	A	D	A	E	B	C	B	E	C	D	C	E
Minerals																
Mean percentage by weight	69	78	56	31	70	6	62	37	75	36	77	35	30	5	38	39
Standard deviation	22	11	26	14	31	2	28	16	9	10	16	14	23	0	10	12
Differences between means	9		25		64		25		39		42		25		1	
Degrees of freedom	13		9		5		14		7		17		1		12	
t-value	1.6		2.9		5.1		3.0		12.4		11.5		1.6		0.1	
Combustion products																
Mean percentage by weight	22	16	29	43	27	86	31	61	16	40	15	59	38	95	38	59
Standard deviation	25	10	26	13	32	19	29	18	10	13	12	15	16	0	15	14
Difference between means	6		14		59		30		24		44		57		21	
Degrees of freedom	13		9		5		14		7		17		1		12	
t-value	1.1		2.3		2.9		3.5		6.3		11.3		5.0		4.0	

Table 4. SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS

Minerals

Analysts	Probability associated with t	Difference between means
A B	$0.10 < P < 0.20$	Not significant
A C	$P \approx 0.02$	Significant
A D	$0.001 < P < 0.005$	Significant
A E	$0.005 < P < 0.01$	Significant
B C	$P < 0.001$	Extremely significant
B E	$P < 0.001$	Extremely significant
C D	$0.30 < P < 0.40$	Not significant
C E	$P > 0.90$	Not significant

Combustion Products

A B	$0.25 < P < 0.30$	Not significant
A C	$0.025 < P < 0.05$	Significant
A D	$0.025 < P < 0.05$	Significant
A E	$0.001 < P < 0.05$	Significant
B C	$P < 0.001$	Extremely significant
B E	$P < 0.001$	Extremely significant
C D	$0.10 < P < 0.20$	Not significant
C E	$0.001 < P < 0.005$	Significant

Table 5a. SAMPLES ANALYZED BY MORE THAN TWO ANALYSTS[a]

Minerals				Combustion products			
B	C	E		B	C	E	
74	32	45		16	23	52	
74	24	39		16	34	61	
63	30	39		28	50	61	
75	39	30		5	41	70	
84	56	23		6	29	77	
A	B	E		A	B	E	
66	78	50		20	10	48	
75	77	26		15	15	73	
86	93	47		10	7	39	
A	C	E		A	C	E	
63	50	45		27	28	55	
10	31	39		85	68	58	
A	C	D		A	C	D	
80	14	5		18	49	95	
A	C	D	E	A	C	D	E
87	46	5	66	8	26	95	27

[a] All numbers are percentage by weight

Table 5b. SAMPLES ANALYZED BY MORE THAN TWO ANALYSTS[a]

Biologicals				Rubber			
B	C	E		B	C	E	
7	39	2		5	6	0	
5	28	0		5	14	0	
5	4	0		4	16	0	
0	0	0		20	20	0	
0	0	0		10	15	0	
A	B	E		A	B	E	
11	6	2		3	6	0	
0	0	1		9	8	0	
1	0	14		3	0	0	
A	C	E		A	C	E	
0	0	0		2	2	0	
0	1	3		4	0	0	
A	C	D		A	C	D	
0	12	0		2	25	0	
A	C	D	E	A	C	D	E
1	3	0	7	4	25	0	0

[a] All numbers are percentage by weight

Table 6. CONSISTENCY OF INDIVIDUAL MICROSCOPISTS

Analyst	Average percent difference between observations	Number of comparisons
Minerals		
Analyst A	18	8
Analyst B	13	7
Analyst E	49	2
Combustion products		
Analyst A	56	8
Analyst B	25	7
Analyst E	48	2
Biologicals		
Analyst A	85	8
Analyst B	81	7
Analyst E	34	2
Rubber		
Analyst A	118	8
Analyst B	117	7
Analyst E	0	2

Table 7. CONSTITUENT ANALYSIS: B C[a]

Components	B	C	Difference (B – C)
Minerals	75	36	39
Quartz	29	16	13
Calcite	34	6	28
Feldspars	3	12	-9
Hematite	8	2	6
Mica	—	—	—
Coal	—	—	—
Combustion products	16	40	-24
Soot:			
Oil	13	6	7
Coal	1	7	-6
Fine soot	—	1	-1
Glassy fly ash	2	—	2
Incinerator fly ash	—	27	-27
Burned wood	—	—	—
Burned paper	—	—	—
Magnetite	—	—	—
Biologicals	2	10	-8

[a] All numbers represent percent contribution to the total TSP level and are mean values

SECTION V

SUMMARY RESULTS

This section presents composite summary results of the microscopic analyses. This serves not only to give an overview of the results and to facilitate comparison but also, hopefully, to minimize any systematic biases and other inaccuracies discussed in the preceding section. In Table 8 the microscopy results for each city have been averaged by the generic type of material present. It can be seen that in every study city except Chattanooga more than half of the mass of the observed particles were from minerals. Table 9, which is a composite of all the results presented in the preceding table, shows that minerals average 65 percent of the observed mass and combustion products only 25 percent.

In Table 10 all filters except the NASN filters have been averaged by monitor site classification. These composite results show the effect of land use in the vicinity of the monitor on the composition of suspended particulate matter. In order to normalize for the differences in concentration at the various site types, the average percentages for the major component classifications have been multiplied by the average concentration for the filters included in each group as shown in Table 11. It should be emphasized that the optical microscope does not permit identification of particles smaller than about 1 μm. Based upon the experience of the microscopists involved an average of about 15 percent of the mass is submicrometer in size and invisible to the analyst. Therefore, in preparing the table it was assumed that 15 percent of the mass is invisible to the microscopist.

The average particle size for each of the major visible components is presented in Table 12. The average size of the mineral fraction, 8 μm, is consistent with the average sizes of the principal components. However, the average size reported for combustion products, 5 μm, is surprisingly low in view of the average size of the individual components within that group. This may be due in part to the fact that the filters for which sizing was done for the individual components are not necessarily the same filters that comprise the combustion products group in this case. For some filters the size range was reported only for the combustion products group as a whole because the individual components comprised less than 5 percent of the observed particulate.

The average size of the biological material is quite large but understandable in terms of its source and aerodynamic shape. The very large average particle size reported for rubber (43 μm), however, is somewhat harder to understand. The generation of large rubber particles by mechanical abrasion is easily understood, but it is difficult to explain how such large particles can be transported over substantial horizontal or vertical distances.

Table 8. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN 14 STUDY CITIES

City	Baltimore[a]		Birmingham[a]		Chattanooga		Cincinnati		Cleveland		Denver		Miami[b]	
No. of filters	27		22		21		20		21		20		3	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(69)	52-88	(66)	14-90	(36)	3-96	(51)	24-88	(51)	28-85	(81)	62-97	(79)	75-83
Quartz	31	10-50	25	8-67	10	<1-30	19	5-63	18	5-35	55	37-84	9	7-10
Calcite	18	2-41	24	3-52	16	2-93	22	5-50	17	6-40	11	1-35	62	60-65
Feldspars	3	0-6	<1	0-4	8	0-20	3	0-10	4	0-10	7	0-15	4	4
Hematite	15	2-46	17	3-65	2	0-12	6	<1-45	12	2-50	5	1-18	4	4
Mica	<1		<1	0-2			<1		<1		3	0-6		
Other	2	0-46	<1	0-3	<1	0-3	<1		<1		<1			
Combustion Products	(25)	11-61	(22)	2-86	(35)	8-78	(44)	9-84	(40)	10-70	(7)	1-19	(9)	7-12
Soot:														
Oil	9	0-60	4	0-86	7	0-40	9	0-52	9	0-30			4	4
Coal	5	0-52	2	0-10	14	0-40	6	0-20	12	0-25	1	0-20	3	2-4
Misc. soot	4	0-50	12	0-71			<1		<1		4	0-14		
Glassy fly ash	6	0-42	3	0-20	5	0-76	24	1-66	15	4-55	1	0-5	2	1-4
Incinerator fly ash	<1		<1		9	0-26	4	0-30	2	0-10			<1	
Burned wood	<1						<1							
Burned paper	<1		<1				<1						<1	
Magnetite							<1		2	0-15				
Carbon black											1	0-19		
Other	1	0-12	1	0-15										
Biological Material	(3)	<1-11	(2)	0-8	(16)	0-90	(1)	<1-5	(1)	<1-5	(1)	0-7	(<1)	
Pollen	<1		<1		7	0-25	<1		1	0-5	<1	0-4	<1	
Spores	<1		<1		<1	0-2	<1		<1		<1		<1	
Paper	<1		<1		<1	0-2	<1		<1		<1		<1	
Starch	1	0-8	<1		1	0-5	<1	0-1	<1		<1		<1	
Misc. plant tissue	2	0-10	2	0-8	8	0-80	1	0-5	<1		1	0-7	<1	
Leaf trichomer														
Miscellaneous	(3)	0-26	(10)	0-50	(13)	0-45	(4)	<1-20	(8)	tr-22	(11)	0-32	(12)	10-15
Iron or steel	1	0-10	2	0-25	<1	0-4	<1		2	0-20	<1		<1	
Rubber	2	0-26	8	0-50	13	0-45	4	0-20	6	0-20	11	0-32	12	10-15
Other									<1					

Table 8 (continued). CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN 14 STUDY CITIES

City	Oklahoma City		Philadelphia[a]		Providence		St. Louis		San Francisco		Seattle		Washington, D.C.	
No. of filters	27		26		25		26		14		23		25	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(88)	63-99	(64)	6-93	(64)	28-92	(75)	21-99	(52)	29-73	(60)	30-96	(70)	39-87
Quartz	29	10-65	29	2-60	39	11-71	26	4-50	25	15-50	35	7-65	31	15-60
Calcite	45	15-75	19	1-68	7	2-31	40	16-68	7	2-16	9	1-20	15	5-45
Feldspars	3	<1-4	2	0-5	7	0-20	2	0-20	18	6-35	10	0-28	3	2-4
Hematite	11	0-30	15	0-40	8	0-18	7	0-30	2	0-8	5	1-15	20	10-50
Mica	<1		<1		3	0-15			<1		<1		<1	
Other							<1	0-5			1	0-4	<1	
Combustion Products	(8)	1-31	(33)	6-89	(22)	4-68	(21)	1-79	(29)	10-50	(27)	1-62	(23)	5-49
Soot:														
Oil	5	1-25	8	0-60	12	0-63	2	0-5	3	0-8	10	0-25	13	2-30
Coal	2	<1-4	2	0-15	2	0-15	<1	0-2	9	0-25	6	0-22	3	<1-5
Misc. soot			18	0-88	4	0-27	16	0-79	<1	0-2	1	0-16		
Glassy fly ash	1	0-3	5	0-30	2	0-29	2	0-10	1	0-10	<1		7	<1-20
Incinerator fly ash	<1		<1		1	0-14	<1	0-2	15	0-45	9	0-45	<1	
Burned wood	<1		<1				<1		1	0-10	<1		<1	
Burned paper	<1		<1				<1				<1		<1	
Magnetite									<1	0-2	1	0-6		
Carbon black					1	0-10								
Other														
Biological Material	(<1)	<1-4	(1)	0-10	(1)	0-5	(<1)	0-5	(3)	tr-10	(3)	tr-26	(5)	<1-47
Pollen	<1		<1		<1		<1		2	tr-5	1	0-20	4	<1-45
Spores	<1	<1-2	<1		<1		<1		<1		<1	0-2	<1	
Paper	<1		<1		<1	0-2	<1		<1		1	0-3	<1	
Starch	<1	0-1	1	0-10	<1		<1		<1		<1	0-2	<1	
Misc. plant tissue	<1	<1-2	<1		1	0-4	<1	0-5	1	0-5	<1	0-2	1	0-3
Leaf trichomer											1	0-18		
Miscellaneous	(4)	<1-30	(2)	0-30	(13)	0-35	(4)	0-10	(16)	0-35	(10)	<1-40	(2)	<1-25
Iron or steel	<1		<1		<1		<1				<1	0-2	<1	
Rubber	4	0-30	2	0-30	13	0-35	4	0-10	16	0-26	10	0-40	2	0-25
Other									<1	0-10	<1	0-15	<1	0-10

[a] Excludes filter analyses of NASN site samples

[b] Filter analysis of NASN site samples only

Table 9. U.S. COMPOSITE SUMMARY OF FILTER ANALYSES[a]

No. of filters	300	
Components	Quantity, percent	
	Average	Range
Minerals	(65)	3-99
Quartz	29	<1-84
Calcite	21	1-93
Feldspars	5	0-35
Hematite	10	0-65
Mica	<1	0-15
Other	<1	0-46
Combustion Products	(25)	1-89
Soot:		
Oil	7	0-86
Coal	5	0-52
Misc. soot	5	0-88
Glassy fly ash	6	0-30
Incinerator fly ash	2	0-45
Burned wood	<1	0-10
Burned paper	<1	0-<1
Magnetite	<1	0-15
Carbon black	<1	0-19
Other	<1	0-15
Biological Material	(3)	0-90
Pollen	1	0-45
Spores	<1	0-2
Paper	<1	0-3
Starch	1	0-10
Misc. plant tissue	1	0-8
Leaf trichomer	<1	0-18
Miscellaneous	(7)	0-50
Iron or steel	<1	0-25
Rubber	7	0-50
Other	<1	0-15

---

[a] U.S. summary based on the filter analysis of the 14 study cities, located within the 48 contiguous states

Table 10. COMPOSITE SUMMARY OF FILTER ANALYSES BY SITE CLASSIFICATION[a]

Site classification	Commercial		Residential		Industrial		Undeveloped	
No. of filters	114		90		71		11	
No. of sites	29		21		19		5	
Average concentration, µg/m³	120		92		166		86	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(63)	6-99	(65)	3-99	(62)	9-96	(90)	79-99
Quartz	28	2-80	31	<1-84	27	2-70	32	15-60
Calcite	20	1-75	18	2-70	20	0-93	40	10-60
Feldspars	6	0-35	4	0-20	4	0-45	3	<1-4
Hematite	9	0-45	12	0-65	10	1-50	15	5-50
Mica	<1	0-6	<1	0-15	<1	0-6	<1	
Other	<1	0-5	<1	0-5	1	0-46		
Combustion Products	(26)	2-86	(25)	3-84	(30)	1-89	(8)	1-18
Soot:								
Oil	8	0-86	9	0-63	6	0-40	5	1-10
Coal	4	0-34	5	0-52	6	0-40	2	<1-4
Misc. soot	7	0-84	3	0-77	7	0-88		
Glassy fly ash	4	0-55	6	0-66	7	0-76	1	<1-4
Incinerator fly ash	3	0-45	1	0-20	3	0-45	<1	
Burned wood	<1		<1	0-1	<1	2-10	<1	
Burned paper	<1		<1	0-1			<1	
Magnetite	<1		<1	0-8	1	0-15		
Carbon black			<1	0-19				
Other			<1	0-15	<1	0-12		
Biological Material	(2)	0-47	(4)	<1-90	(2)	0-33	(1)	<1-4
Pollen	1	0-45	2	0-30	1	0-25	<1	
Spores	<1	0-2	<1	0-3	<1		<1	0-2
Paper	<1	0-2	<1	0-3	<1	0-2	<1	
Starch	<1	0-10	<1	0-5	<1	0-10	<1	
Misc. plant tissue	1	0-17	2	0-80	1	0-7	1	0-3
Leaf trichomes					<1	0-6		
Miscellaneous	(9)	0-50	(6)	0-28	(5)	0-45	(1)	<1-6
Iron or steel	<1	0-4	<1	0-2	1	0-25	<1	
Rubber	9	0-50	6	0-28	5	0-45	1	0-6
Other	<1	0-10	<1	0-10	<1	0-15		

[a] Excludes all NASN filters

Table 11. ESTIMATES OF AVERAGE FILTER LOADINGS BY SITE CLASSIFICATION

Component	Average loading, $\mu g/m^3$			
	Commercial	Residential	Industrial	Undeveloped
Mineral	64	51	87	66
Combustion products	27	19	42	6
Biological material	2	3	3	<1
Misc. (mostly rubber)	9	5	9	<1
Assumed <1 µm	18	14	25	13
Total	120	92	166	86

Table 12. COMPOSITE SUMMARY OF PARTICLE SIZE BY COMPONENTS

Component	Average size, µm	Average size range, µm	No. of filters included in averaging
Minerals	(8)	<1-62	153
Quartz	11	2-65	154
Calcite	9	1-45	148
Hematite	3	<1-39	89
Combustion products	(5)	<1-58	92
Oil soot	13	4-106	107
Coal soot	30	6-66	52
Glassy fly ash	12	2-38	35
Biological material	(24)	5-82	13
Pollen	35	13-39	15
Rubber	(43)	13-135	94

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Combustion products	27	19	42	6
Biological material	2	3	3	<1
Misc. (mostly rubber)	9	5	9	<1
Assumed <1 µm	18	14	25	13
Total	120	92	166	86

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Hematite	3	<1-39	89
Combustion products	(5)	<1-58	92
Oil soot	13	4-106	107
Coal soot	30	6-66	52
Glassy fly ash	12	2-38	35
Biological material	(24)	5-82	13
Pollen	35	13-39	15
Rubber	(43)	13-135	94

SECTION VI

CITY STUDIES

The results for each of the 14 cities are presented below. Although the results of each microscopic analysis are presented, the implications of the quality control discussion must be kept in mind. The results of individual analyses have been rounded of, as detailed in Table 13, in order to present only as much detail as appears justified and can be comprehended easily. The composite summary tables and replicate analyses tables, however, have maintained the actual mass percent reported to allow better comparison.

DENVER

The Denver AQCR represents a lightly industrialized area with above average heating requirements and less than average amount of rain. There have been no real trends in TSP levels during the past 6 years in the AQCR although Denver County has shown some improvement in its air quality since 1965. The primary annual air quality standard is being exceeded at most sites around the AQCR, and the secondary annual air quality standard is being exceeded at all but one site. The highest annual geometric mean was 131 $\mu g/m^3$, 8 percent higher than that used in the SIP for strategy planning. Violations of the 24-hour standards have also been frequent, with the secondary standard exceeded occasionally at most of the monitors in 1974. The reader is directed to Volume III of this report for a complete discussion of the subject city.

The spatial distribution of the air quality is primarily the result of the topography with highest levels near the river bed and the levels decreasing in the suburban and rural areas on higher ground. The countywide geometric mean of all stations in Denver County was 97 μg/m^3.

The locations of the four sites that were selected for filter analysis in Denver are shown in Figure 1. Table 14 details the pertinent characteristics of these sites, and Table 15 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 16. The results of each of 20 samples submitted for routine analysis are presented in Table 17. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 18. Six filters underwent replicate analyses, and the results of this task are presented in Table 19.

The composite particulate characterization for all filters from Denver that underwent routine analysis, presented in Table 20, shows that minerals predominate the particulate material. Of the 14 study cities, only one showed higher average percent minerals than Denver. The high mineral contribution apparently is a citywide phenomenon with the average of each of the four sites studied ranging from 79 percent to 87 percent. The major mineral constituent is quartz, which by itself comprises over half of the mass of the observed particles.

The relative contribution of combustion products to the Denver aerosol appears to be very low. It is, in fact, the lowest percent contribution for the category in any of the 14 study cities. If the microscopy results are a reliable indicator of the makeup of all the particulate collected on the hi-vol filters, then the weighted average concentration of combustion products on the 20 Denver filters would be only 11 μg/m^3.

Denver was also one of just two study cities that were found to have a higher percent contribution of rubber than combustion products. The average percent rubber content in Denver was not excessively high compared to the other study cities (Denver was fifth highest), but it does support the theory of fugitive emissions, especially after road sanding operations, being an important consideration.

Three of the filters from Denver were also submitted for determination of particle size as a function of particle type, as shown in Figures 2 through 4. Two of these filters were also subjected to chemical analysis. The filter from the State Health Department on June 14, 1974, had 4 $\mu g/m^3$ benzene solubles and just over 12 $\mu g/m^3$ total carbon with nearly all of it reported as organic carbon. The filter from the School Administration Building on the same day had over 12 $\mu g/m^3$ benzene solubles and about 15 $\mu g/m^3$ total carbon, again nearly all reported as organic carbon. The State Health Department filter from June 14, 1974, was also selected for detailed physical analysis, and the results are presented in Table 21.

Table 13, **ROUND-OFF VALUES USED IN REPORTS OF INDIVIDUAL FILTER ANALYSES**

Percent reported	Indicated as
0 - 3	0+
4 - 7	1-
8 - 12	1
13 - 15	1+
16 - 17	2-
18 - 22	2
23 - 25	2+
26 - 27	3-
28 - 32	3
33 - 35	3+
36 - 37	4-
38 - 42	4
43 - 45	4+
46 - 47	5-
48 - 52	5
55 - 55	5+
56 - 57	6-
58 - 62	6
63 - 65	6+
66 - 67	7-
68 - 72	7
73 - 75	7+
76 - 77	8-
78 - 82	8
83 - 85	8+
86 - 87	9-
88 - 92	9
93 - 95	9+
96 - 97	10-
98 - 100	10

NOTE: Subcategory quantities reported as 0 - 3 percent have been omitted from the tabulation.

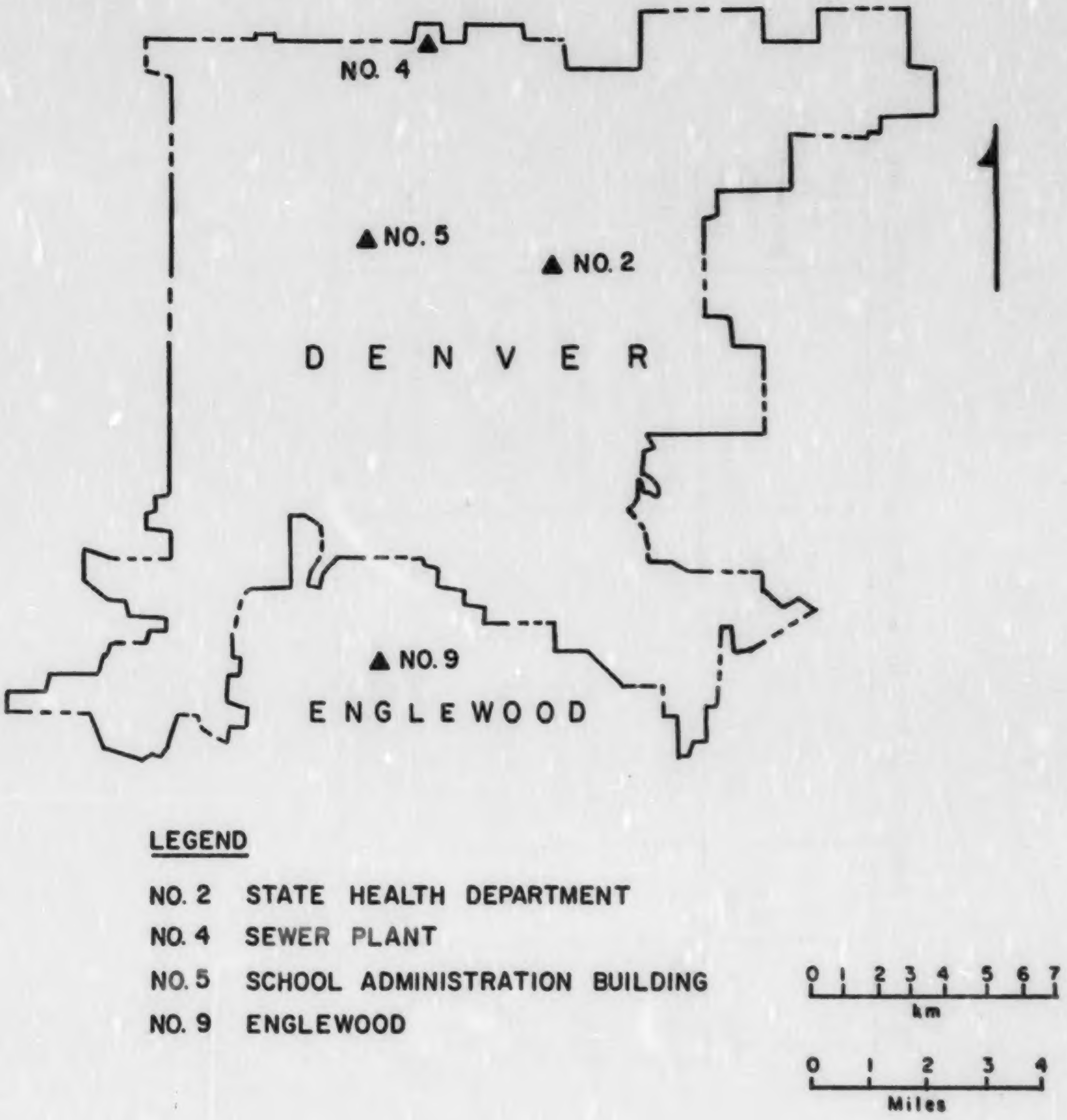
NO. 4
NO. 5
NO. 2
DENVER
NO. 9
ENGLEWOOD
LEGEND
NO. 2 STATE HEALTH DEPARTMENT
NO. 4 SEWER PLANT
NO. 5 SCHOOL ADMINISTRATION BUILDING
NO. 9 ENGLEWOOD
0 1 2 3 4 5 6 7
km
0 1 2 3 4
Miles

Figure 1. Denver TSP monitoring sites selected for filter analyses

Table 14. CHARACTERISTICS OF MONITORING SITES IN THE DENVER AQCR

County	CAPCD no.	Location	Height above ground, feet	Site characteristic	TSP 1974 geometric mean, $\mu g/m^3$
Arapahoe	9	Englewood	20	Residential/ commercial	107
Denver	2	State Health Department	60	Light commercial suburban	74
	4	Sewer Plant	10	Light commercial suburban	131
	5	School Administration Building	50	Center city-commercial	107

Table 15. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (STAPLETON INTERNATIONAL AIRPORT, DENVER)

	Precipitation, in.		Wind speed, mph		Wind direction, deg	
Date	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
1/25/74	0	0	6.0	4.2	C, 220, 210, 200 190, 80, 250, 250	210
6/14/74	0	0.02	7.1	3.3	320, 230, 200, 120 120, 90, 160, 200	150
6/26/74	t	0	10.2	4.8	180, 220, C, 10 50, 260, 130, 180	190
7/20/74	0	0	5.5	1.3	180, 190, 240, 30 80, 20, 310, C	30
12/19/74	0	t	15.2	12.8	310, 360, 270, 270 360, 310, 290, 330	300
12/27/74	0	t	11.2	10.8	210, 190, 190, 210 220, 160, 200, 190	200

Note: C = Calm
t = Trace

Table 16. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE DENVER, COLORADO, NASN SITE NO. 060580001 ($\mu g/m^3$)

	Sulfate		Nitrate	
Year	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	6.65[a]	5.70[a]	3.55[a]	3.13[a]
1973	8.41[a]	7.92[a]	7.36[a]	6.11[a]
1974	4.92[a]	4.80[a]	4.27[a]	4.08[a]

[a] Indicates insufficient data for statistically valid year.

Table 17a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN DENVER AND VICINITY (STATE HEALTH DEPARTMENT — NO. 2)

Date	25 January 1974			14 June 1974			26 June 1974			20 July 1974			19 December 1974			27 December 1974		
TSP ($\mu g/m^3$)	204			77			74			68			76			90		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9)	<1-76	9	(7+)	<1-66	15	(8+)	<1-95	15	(9-)	<1-75	9	(7)	<1-31	15	(8)	<1-60	9
Quartz	8+			4			5+			5			4+			6+		
Calcite				1			1			1-			1					
Feldspars				1			1			1			1			1		
Hematite				1-						2-			1-					
Mica				1-			1-			1-								
Combustion Products	(1-)	<1-12	1	(0+)			(0+)			(0+)			(1-)			(2)	<1-2	1
Soot:																		
Oil																		
Coal	1-																	
Fine soot													1-					
Glassy fly ash																		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Carbon black																2		
Biological Material	(0+)			(0+)			(1-)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1-)			(2+)			(1)			(1)	9-21	12	(3)	9-75	21	(0+)		
Iron or steel																		
Rubber	1-			2+			1			1			3					

Table 17b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN DENVER AND VICINITY (SEWER PLANT — NO. 4)

Date	25 January 1974			14 June 1974			26 June 1974			20 July 1974			19 December 1974			27 December 1974		
TSP ($\mu g/m^3$)	565			111			241			95			143			226		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(9)	<1-80	12	(8)	1-80	12	(9)	<1-75	10	(7)	<1-140		(8)	1-140	15	(8+)	<1-36	6
Quartz	6			4			7			4+			4+			7		
Calcite	1+			2+			1			1+			1+					
Feldspars	1-			1+			1-			1-			1-			1-		
Hematite													1-			1-		
Mica													1-					
Combustion Products	(1-)	<1-18	9	(1)		1	(1-)	<1-20	7	(1-)			(0+)			(1-)		
Soot:																		
Oil																		
Coal																		
Soot	1-			1-												1-		
Glassy fly ash							1-											
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(1-)			(0+)			(1-)			(0+)			(0+)		
Pollen				1-														
Spores																		
Paper																		
Starch																		
Misc. plant tissue										1-								
Miscellaneous	(1-)	5-45	21	(1)	5-80	30	(1-)			(2)	10-175	20	(2)	10-130	30	(1)	9-75	30
Iron or steel																		
Rubber	1-			1						2			2			1		

Table 17c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN DENVER AND VICINITY (SCHOOL ADMINISTRATION BUILDING — NO. 5)

Date	25 January 1974			14 June 1974			26 June 1974			20 July 1974			19 December 1974			27 December 1974		
TSP ($\mu g/m^3$)	436			89			132			74			104			197		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9)	<1-105	15	(8)	<1-25	9	(6)			(7-)	1-75	7	(8+)	<1-60	9	(9)	<1-90	5
Quartz	5			5-			4+	<1-65	3	5			4-			7		
Calcite	3+			2			1	<1-25	5	1			1+					
Feldspars										1-			1			1		
Hematite				1			1-	<1-50	0.5				2-			1-		
Mica																1-		
Combustion Products	(0+)			(1)	<1-5	<1	(4-)	<1-22	1	(0+)			(1+)	<1-75	1	(1)	<1-25	1
Soot:																		
Oil																		
Coal							2-		10									
V.f.soot				1			1+											
Soot particles													1			1-		
Glassy fly ash													1					
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1-)	5-75	27	(1)	5-125	15	(0+)			(3)	4-105	15	(0+)			(0+)		
Iron or steel																		
Rubber	1-			1						3								

Table 17d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN DENVER AND VICINITY (ENGLEWOOD - NO. 9)

Date	25 January 1974			14 June 1974		
TSP ($\mu g/m^3$)	230			114		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(10-)	<1-60	10	(8-)	<1-65	8
Quartz	8			6-		
Calcite	1					
Feldspars				1		
Hematite	1-			1-		
Mica						
Combustion Products	(0+)			(1)	<1-15	1
Soot:						
Oil						
Coal						
Fine soot				1		
Glassy fly ash						
Incinerator fly ash						
Burned wood						
Burned paper						
Magnetite						
Biological Material	(0+)			(0+)		
Pollen						
Spores						
Paper						
Starch						
Misc. plant tissue						
Miscellaneous	(0+)			(1)	10-40	20
Iron or steel						
Rubber						

Table 18. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN DENVER AND VICINITY

Site	State Health Dept. — No. 2		Sewer Plant No. 4		School Administration Bldg. — No. 5		Englewood No. 9	
No. of filters	6		6		6		2	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(80)	68-89	(82)	70-89	(79)	62-91	(87)	76-97
Quartz	56	40-84	54	40-70	49	37-68	68	56-80
Calcite	6	1-11	14	2-25	15	3-35	7	3-10
Feldspars	9	0-12	8	4-15	6	3-12	6	0-11
Hematite	6	2-16	4	1-8	6	2-18	6	5-7
Mica	3	tr-5	2	0-6	3	0-6	<1	
Hornblonde			tr	0-tr	tr	0-tr		
Combustion Products	(5)	1-19	(4)	1-6	(12)	2-36	(6)	2-10
Soot:								
Oil								
Coal	1	0-5	1	0-3	3	0-20		
Fine soot	1	0-4	2	0-5	6	1-14	6	2-9
Soot particles					2	0-12		
Glassy fly ash	<1	0-1	1	0-5	1	0-2	<1	
Incinerator fly ash								
Burned wood								
Burned paper								
Magnetite								
Carbon black	3	0-19						
Biological Material	(1)	<1-4	(3)	1-7	(1)	<1-2	(1)	0-3
Pollen	<1	0-1	1	0-4	<1	0-2	<1	
Spores	<1		<1		<1		<1	
Paper	<1		<1		<1		<1	
Starch	<1		<1		<1		<1	
Misc. plant tissue	1	0-3	2	<1-7	<1	0-1	1	0-2
Miscellaneous	(14)	1-28	(11)	4-19	(8)	0-32	(6)	1-11
Iron or steel			<1	0-1			<1	tr-1
Rubber	14	1-28	11	4-19	8	0-32	6	1-10

Table 19. RESULTS OF REPLICATE ANALYSES OF DENVER FILTERS

Site	School Administration Bldg. — No. 5						Sewer Plant No. 4		State Health Dept. — No. 2			
Date	25 January 1974		14 June 1974		27 December 1974		19 December 1974		25 January 1974		19 December 1974	
TSP ($\mu g/m^3$)	436		89		197		143		204		76	
Laboratory	A	B	A	B	A	A	A	A	A	B	A	A
Analysis	1	1	1	1	1	2	1	2	1	1	1	2
Components												
Minerals	(91)	(25)	(80)	(9)	(91)	(79)	(78)	(89)	(89)	(30)	(68)	(68)
Quartz	52		46		68	60	45	50	84		45	40
Calcite	35		18		3	10	15	25	1		10	20
Feldspars	3		3		10	4	4	4			9	3
Hematite	1		9		4	5	8	10	2		4	5
Mica			4		6	<1	6	<1	2		tr	<1
Combustion Products	(3)	(75)	(10)	(91)	(8)	(16)	(1)	(7)	(6)	(70)	(4)	(12)
Soot:												
Oil		15		5		10		4		15		10
Coal						2		1	5			1
V.f.soot	2		8		7		<1				4	
Glassy fly ash	1	60	2	86	1	4	1	2	<1	55		1
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(1)	(<1)	(<1)	(<1)	(<1)	(<1)	(2)	(<1)	(<1)	(<1)	(<1)	(<1)
Pollen			<1		<1			<1				<1
Spores	<1		<1		<1		<1	<1				<1
Paper					<1			<1			tr	<1
Starch							<1	<1	<1			
Misc. plant tissue	1				<1		2	<1				<1
Miscellaneous	(5)	(<1)	(10)	(<1)	(<1)	(5)	(19)	(4)	(4)	(<1)	(28)	(20)
Iron or steel	<1		tr		tr	<1	<1	<1				<1
Rubber	4		10			5	19	4	4		28	20

Table 20. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN DENVER

No. of filters	20	
	Quantity, percent	
Components	Average	Range
Minerals	(81)	62-97
Quartz	55	37-84
Calcite	11	1-35
Feldspars	7	0-15
Hematite	5	1-18
Mica	3	0-6
Other	<1	
Combustion Products	(7)	1-19
Soot:		
Oil		
Coal	1	0-20
Misc. soot	4	0-14
Glassy fly ash	1	0-5
Incinerator fly ash		
Burned wood		
Burned paper		
Magnetite		
Carbon black	1	0-19
Other		
Biological Material	(1)	0-7
Pollen	<1	0-4
Spores	<1	
Paper	<1	
Starch	<1	
Misc. plant tissue	1	0-7
Leaf trichomes		
Miscellaneous	(11)	0-32
Iron or steel	<1	
Rubber	11	0-32
Other		

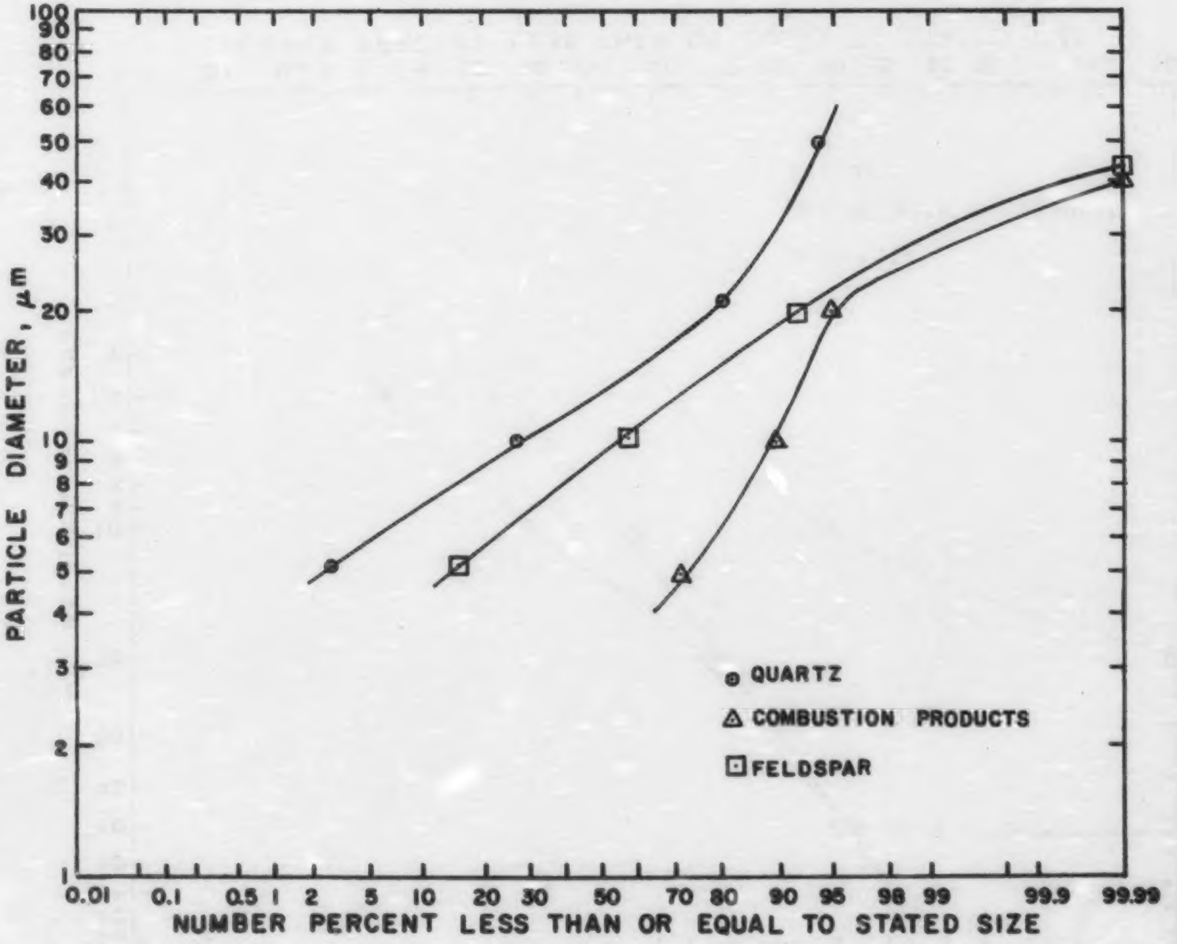

Figure 2. Cumulative size distributions for three particle types, State Health Building, Denver, January 25, 1974

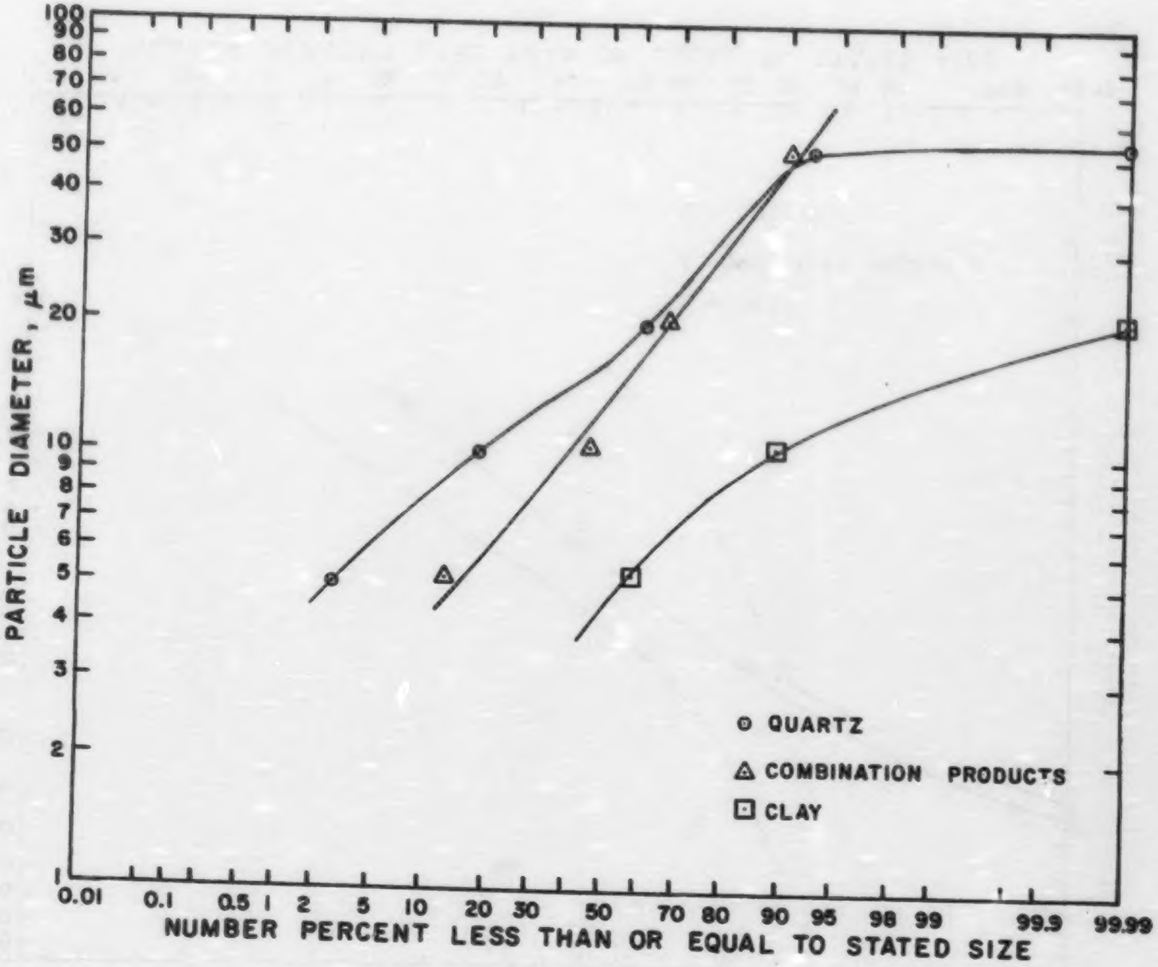

Figure 3. Cumulative size distributions for three particle types, State Health Building, Denver, June 14, 1974

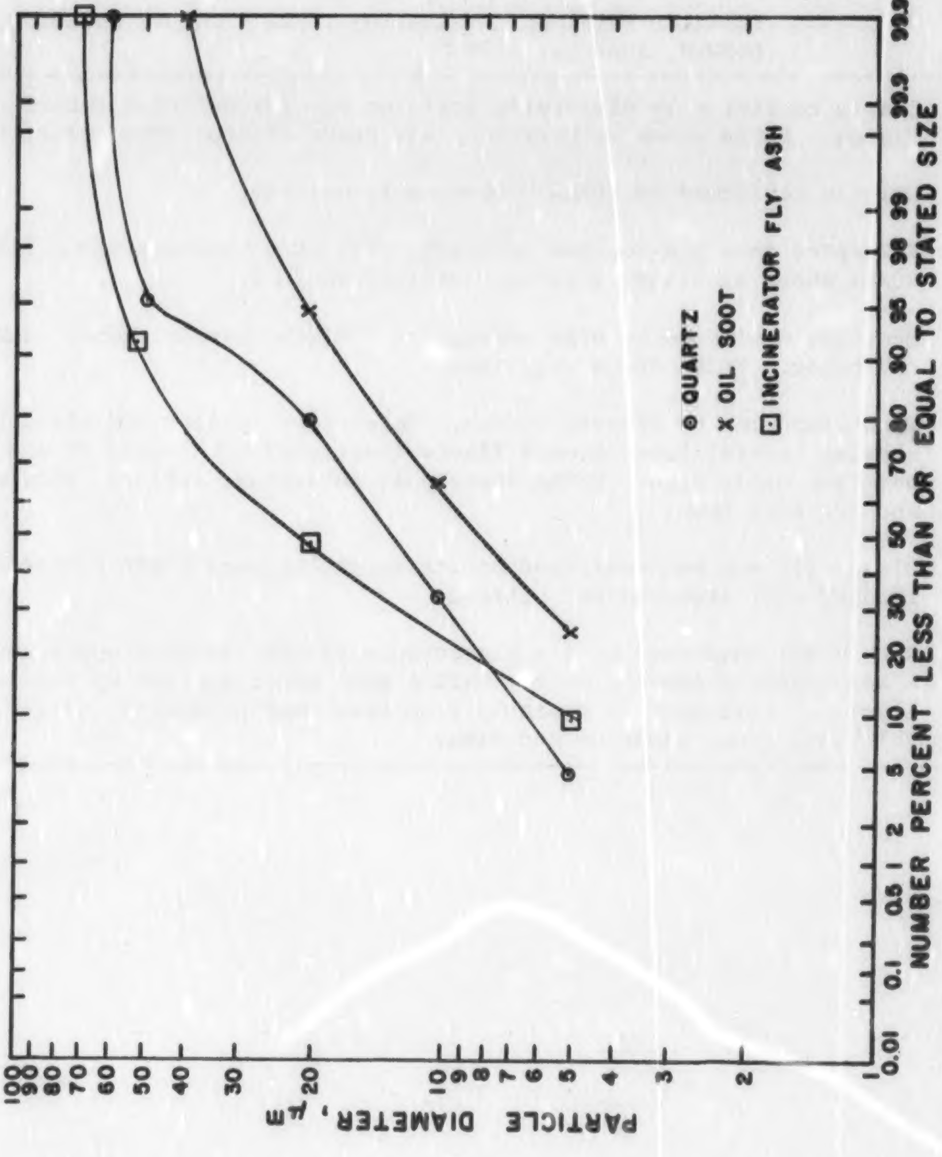

Figure 4. Cumulative size distributions for three particle types, School Administration Building, Denver, June 14, 1974

Table 21. DETAILED PHYSICAL EXAMINATION: STATE HEALTH BUILDING, DENVER, JUNE 14, 1974

A. Quartz confirmed by dispersion staining and (-) uniaxial interference figure. EDXRA shows only silicon and trace of iron (from hematite).

B. Calcite confirmed by EDXRA — shows only calcium.

C. Feldspars show plagioclase twinning, refractive indices above 1.530, EDXRA shows aluminum, silicon, calcium, sodium.

D. Hematite confirmed by high refractive indices, birefringence, and deep red color. EDXRA shows only iron.

E. Mica confirmed by crystal optics. Refractive indices and platy habit, showing biaxial interference figure (centered) with small 2V and negative optic sign. EDXRA shows only potassium, silicon, aluminum and trace of iron.

F. Glassy fly ash was confirmed by its morphology and EDXRA spectrum: showing only aluminum and silicon.

G. Rubber was confirmed by its elastomeric nature, surface appearance and EDXRA spectrum showing mostly carbon with minor amounts of calcium, aluminum, silicon (all probably from road wear products), sulfur, chlorine, iron, titanium and zinc.

BIRMINGHAM

Birmingham, in Jefferson County, Alabama, is a heavy industrial city in a shallow valley at the southwestern end of the Appalachian Mountains. Generally, southern and warm though not subtropical, Birmingham is in the area where major air stagnations are very frequent. It is located in the area of the eastern United States where stagnant high pressure systems are the most frequent, and in addition, the valley topography increases the frequency and severity of nocturnal radiation inversions. Precipitation is moderately heavy (53 inches per year) and plays a major role in determining day-to-day variations in TSP levels. The reader is directed to Volume IV of this report for a complete discussion of the subject city.

Eleven of the 13 hi-vol sites in the county exceed the annual standard frequently, with levels ranging from 84 to 144 $\mu g/m^3$. Three of the sites exceed the 24-hour standard very frequently, and daily loadings in the range 400 to 500 $\mu g/m^3$ do occur. At all but one of the sites in violation, however, levels have been declining significantly since the mid-1960's, and especially since the early 1970's. Decreases of about 50 percent have occurred at the industrial sites that still have the highest levels.

The locations of the six sites that were selected for filter analysis in Birmingham are shown in Figure 5. Table 22 details the pertinent characteristics of these sites and Table 23 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 24. The results for each of the 22 filters submitted for routine analysis from all sites except the NASN site are presented in Table 25. The results for each site have been averaged to give a composite of the particulate composition as shown in Table 26. Seven filters underwent replicate analyses and the results of this task are presented in Table 27.

Birmingham was one of three study cities selected for particulate trends analysis. To accomplish this task, four to six filters for each calendar year between 1970 and 1974 from the NASN sampling site were selected for microscopic analysis. The results of each filter analysis are presented in Table 28 and a composite summary for each year is presented in Table 29. From the limited number of filters analyzed it is difficult to discern any consistent trend in the composition of the particulate matter although there are apparent variations year to year. The contribution of biological material was high in 1971 but that is primarily due to one observation day (April 11, 1971) which had an inordinate amount of pollen. Similarly, the higher average rubber content for 1970 was due to one observation day (January 2, 1970) which reported excessive amounts. The data do, however, indicate an increase in the percent rubber for 1974. Not only was the average amount of rubber higher, but that constituent was observed on four of the six filters analyzed at that site for 1974.

Table 30, which presents the citywide composite summary for the 22 non-NASN filters that were analyzed for 1974, shows a rubber content comparable to that observed at the NASN site for 1974. It is also interesting to note from Table 26 that the levels of rubber detected at the out-of-town residential sites (Leeds and Mountain Brook) were much lower than those at the in-town sites. The average percent contribution of rubber in Birmingham is quite typical of the other study cities, however, being seventh out of 14 in that category. It is also typical as far as average mineral content, again ranking seventh out of 14 study cities, and for combustion products, ranking ninth highest.

The individual constituents within the major particulate categories are somewhat unusual in Birmingham, however. The average amount of hematite, the principal ore of iron, was reported as 17 percent, the second highest of the 14 study cities. In addition, iron and/or steel was detected on 17 of the 22 filters and ranged as high as 25 percent of the total mass visible to the microscopist. The average percent iron and steel, although only 2 percent, was the highest observation for that category of the 14 cities. It is also apparent that the analysts had a difficult time determining the precise nature and source of much of the combustion products. In few cities did as much of the combustion-related material get categorized as "miscellaneous soot." It is likely that this confusion was caused by the complex nature of the emissions of the coke ovens and steel furnaces which predominate the industrial activity in the Birmingham area.

Three of the filters from Birmingham were also submitted for determination of particle size as a function of particle type, as shown in Figures 6 through 8. Two of these samples were also subjected to chemical analyses. The sample from North Birmingham on October 26, 1974 had 17 $\mu g/m^3$ benzene solubles and nearly 75 $\mu g/m^3$ total carbon with most reported as organic carbon. The sample from the downtown site on October 14, 1974 had just over 7 $\mu g/m^3$ benzene solubles and nearly 50 $\mu g/m^3$ total carbon, again nearly all reported as organic carbon. This latter sample was also selected for detailed physical analysis, and the results are presented in Table 31.

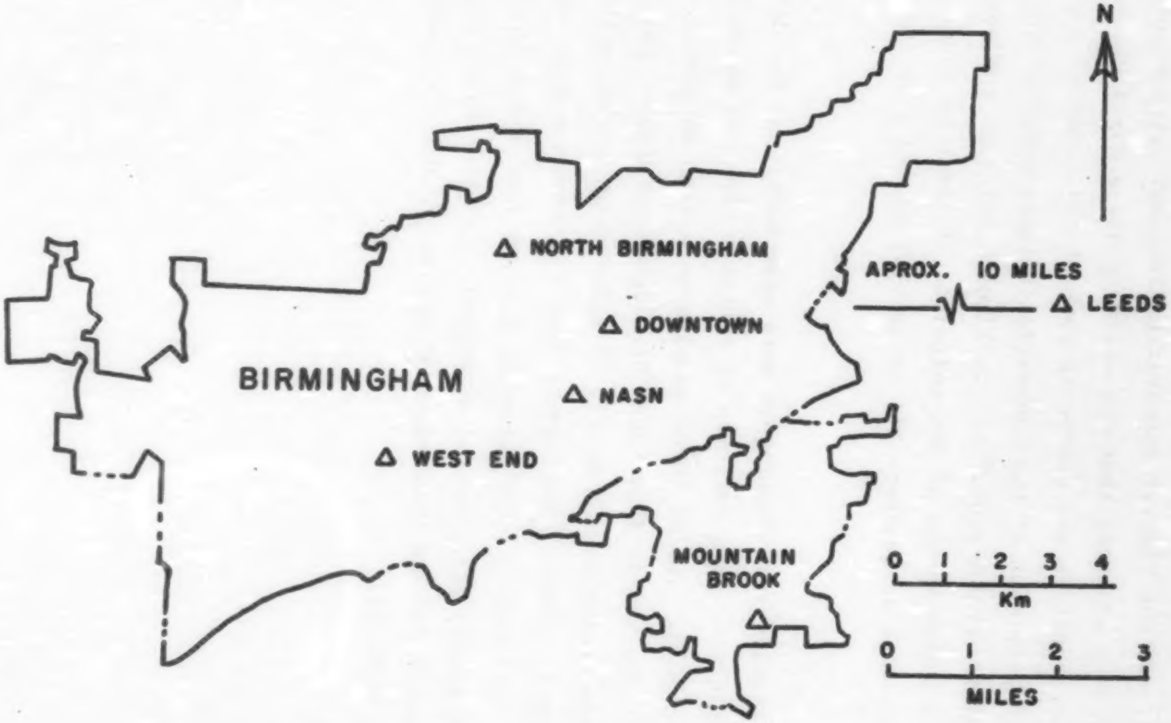
N
NORTH BIRMINGHAM
APROX. 10 MILES
LEEDS
DOWNTOWN
BIRMINGHAM
NASN
WEST END
MOUNTAIN BROOK
0 1 2 3 4
Km
0 1 2 3
MILES

Figure 5. Birmingham TSP monitoring sites selected for filter analysis

Table 22. SAMPLING SITE DESCRIPTION AND LAND USE CHARACTERISTICS

Site	1974 geometric mean	Predominant influence	Sampler height, ft	Immediate site location	Nearby land use
North Birmingham	144	Industrial	6	Grassy area in industrial neighborhood	Industrial, decrepit residential; foundry 50 ft across street, two others nearby; old house adjacent
Leeds	143	Industrial	6	Small town backyard with trees	Small town central business area within two blocks; major cement mill several blocks south
NASN	96	Major CBD	45	Rooftop office building near intersection	Dense CBD and heavy traffic; medical center complex with parking area adjoining
Downtown	94	Major CBD	10	Corner Post Office official parking lot	Dense CBD, heavy traffic; expressway four blocks NW, railroad tracks four blocks SE
West End	88	Dense residential	6	Grassy island in street intersection	Older residential; minimal commercial at intersection; relatively light traffic
Mountain Brook	47	Open residential	6		Open, wooded residential

Table 23. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (MUNICIPAL AIRPORT, BIRMINGHAM)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
1/02/70	0	t	1.7	1.5	C, C, C, C 220, 280, C, C	260
3/09/70	0	0	4.6	2.6	60, C, C, 310 260, 280, 210, 50	270
6/23/70	0	0	4.2	4.0	C, C, C, 340 330, 350, 10, C	350
7/04/70	0	0	6.9	5.6	60, C, 270, 20 320, 330, 20, 10	350
12/05/70	t	0	4.5	1.8	C, C, C, 90 210, 270, 320, 10	310
4/11/71	0	0	4.2	0.3	30, C, C, 30 200, 270, 170, 60	260
5/04/71	0	0	4.0	1.1	50, 60, C, C 320, 260, 200, 360	270
5/21/71	0	t	7.6	6.6	C, 130, C, 360 10, 20, 10, 80	20
7/01/71	1.06	0.49	3.0	1.7	C, C, C, 270 280, 160, 160, C	250
1/10/72	2.74	0.71	6.3	4.3	190, 180, 320, C 200, 150, 150, C	190
6/02/72	0	0	1.6	1.4	C, C, C, 30 C, 330, 350, C	350
7/08/72	0	0	3.0	2.6	C, C, C, 160 210, 130, 130, C	160
11/17/72	0	t	7.3	5.8	280, 320, 350, 330 290, 350, 360, 80	330

Table 23 (continued). METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (MUNICIPAL AIRPORT, BIRMINGHAM)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
1/04/73	0	0.63	1.9	1.8	C, C, C, C 310, 290, 320, C	310
2/21/73	0	0	5.2	4.9	C, C, C, C 320, 320, 290, 350	320
9/25/73	0	0	9.1	8.5	20, 50, 40, 90 90, 90, 90, 90	80
10/19/73	0	0	3.2	2.3	C, C, C, 150 40, 360, 30, C	30
8/09/74	0	0.26	3.5	1.1	90, 150, C, 170 280, 350, 360, C	320
8/21/74	0	0	5.8	5.2	90, 60, 90, 120 50, 90, 80, 30	80
8/27/74	0.34	0	1.7	0.1	C, C, C, C 150, 360, 240, C	110
10/14/74	0	0	3.9	3.1	C, C, 10, 160 160, 160, 130, 70	150
10/15/74*	0.08	0	4.8		160, 160, 160, 130 70, 150, 200, 160	
10/26/74	0	0	3.2	1.2	40, C, C, 180 340, 280, 90, 50	330
11/01/74	0	0	5.5	2.8	30, 140, 120, 150 210, 180, 40, 30	150

*From 0800 10/14/74 to 0800 10/15/74 (for Leeds sample dated 10/15/74)

Note: C = Calm
t = Trace

Table 24. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE BIRMINGHAM, ALABAMA, NASN SITE NO. 010380003 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	12.19	10.96	2.91	2.65
1973	11.82	11.17	3.68	3.42
1974	16.07	14.16	4.07	3.05

Table 25a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (DOWNTOWN AUX.)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP (μg/m³)	102			82			123			139			214			112		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7-)	1-30	6	(8+)	<1-65	18	(8+)	1-30	12	(1+)	<1-30	7	(7-)	<1-29	9	(4+)	1-80	7
Quartz	3			1			1			1			3			1		
Calcite	3+			4			3						3			3		
Feldspars																		
Hematite	1			3+			4+											
Mica													1			1-		
Combustion Products	(1)	<1-75	5	(1-)			(1+)	2-96	5	(9-)	1-59	9	(2+)	<1-36	1	(0+)		
Soot:																		
Oil										9-								
Coal																		
Soot				1-			1											
V.F.soot													2+					
Glassy fly ash	1																	
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(1-)	6-75	15
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																1-		
Miscellaneous	(2)	10-90	30	(1)			(1-)			(0+)			(1)	9-60	28	(5)	2-115	50
Iron or steel																		
Rubber	2			1									1			(5)		

Table 25b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (NO. BIRMINGHAM AUX.)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP ($\mu g/m^3$)	123			198			228			227			351			236		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(8)	1-75	8	(7-)	1-95	15	(5)	<1-65	8	(7-)	<1-60	12	(6+)	<1-45	12	(7+)	1-45	9
Quartz	2+			2-			1-			2			2+			3+		
Calcite	5			2+			2			3			3			3		
Feldspars																		
Hematite				2+			2+			1+			1			1		
Mica																		
Combustion Products	(1+)	<1-30	7	(1-)	1-26	13	(4)	1-75	6	(3+)	<1-70	4	(3)	1-150	12	(2)	<1-65	6
Soot:																		
Oil																		
Coal	1-												3					
Soot				1-			3-			3+						2		
Glassy fly ash	1																	
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(1-)	4-70	30	(<1)			(<1)			(1-)	10-300	18
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue							1-									1-		
Miscellaneous	(1-)	8-55	25	(3-)	2-18	10	(1-)			(<1)			(<1)			(<1)		
Iron or steel				2+														
Rubber	1-						1-											

Table 25c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (WEST END)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP ($\mu g/m^3$)	111			83			103			103			199			71		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(7)	<1-25	9	(7)	<1-45	18	(8+)	1-67	5	(8)	<1-50	7	(6)	<1-80		(8+)	1-97	9
Quartz	3+			4			1			2+			2			3+		
Calcite	1+			1			1			4+			3			4		
Feldspars																		
Hematite	2			2			6+			1			1			1		
Mica																		
Combustion Products	(1)			(2)	3-98	20	(0+)			(1-)	<1-45	11	(1)	<1-26	1-2	(1-)	<1-45	1
Soot:																		
Oil																		
Coal				1									1					
Soot										1-								
Glassy fly ash	1-																	
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Fused matter				1+														
Biological Material	(0+)			(1)	3-120	80	(0+)			(0+)			(1-)	9-36	12	(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue				1									1-					
Miscellaneous	(2)	3-100	35	(0+)			(1+)	10-70	33	(1)	8-150	32	(2+)	10-195	35	(1-)	12-80	29
Iron or steel																		
Rubber	2						1			1			2+			1-		

Table 25d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (MOUNTAIN BROOK AND LEEDS)

Site	Mountain Brook									Leeds		
Date	9 August 1974			16 October 1974			26 October 1974			15 October 1974		
TSP ($\mu g/m^3$)	48			50			78			231		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(3)	1-12	4	(7+)	<1-150		(9)	<1-60	9	(7)		
Quartz	1			5+			7-			3-	<1-50	6
Calcite	1			1-						3	<1-50	6
Feldspars										1-		
Hematite	1			2-			2			1	<1-75	0.5
Mica												
Combustion Products	(7)	<1-5	1	(2)	<1-21	4	(1-)	<1-41	1	(3)		
Soot:												
Oil										1	<1-100	0.5
Coal										1	<1-70	8
Soot	7											
Glassy fly ash				2						1	<1-45	6
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(0+)			(0+)			(0+)			(<1)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(0+)			(1-)			(1-)			(<1)		
Iron or steel												
Rubber				1-			1-					

Table 26. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY

Site	Down Town Aux.		West End		No. Birmingham Aux.		Mountain Brook		Leeds
No. of filters	6		6		6		3		1
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent
Components	Average	Range	Average	Range	Average	Range	Average	Range	–
Minerals	(60)	14-85	(74)	58-85	(67)	52-80	(64)	28-90	(70)
Quartz	16	8-30	27	10-38	21	7-35	44	10-67	26
Calcite	26	1-40	25	8-45	31	20-52	5	3-8	30
Feldspars									4
Hematite	18	3-45	22	8-65	14	3-25	15	10-20	10
Mica			<1	0-2	<1				
Other			<1	0-2	1	0-3			
Combustion Products	(24)	2-86	(10)	3-22	(24)	6-38	(32)	5-71	(30)
Soot:									
Oil	14	0-86					<1		10
Coal	<1	0-3	3	0-10	1	0-4	<1		10
Soot	8	0-24	1	0-5	21	0-38	25	0-71	
Glassy fly ash	2	0-9	3	1-6	2	0-9	7	0-20	10
Incinerator fly ash									<1
Burned wood									
Burned paper									<1
Magnetite									
Other			3	0-15					
Biological Material	(1)	0-5	(3)	<1-8	(2)	<1-5	(<1)	0-1	(<1)
Pollen	<1		<1		<1		<1		<1
Spores	<1		<1		<1		<1		<1
Paper	<1		<1		<1		<1		<1
Starch	<1		<1		<1		<1		<1
Misc. plant tissue	1	0-5	3	<1-8	2	<1-5	<1		<1
Miscellaneous	(15)	0-50	(13)	2-25	(7)	<1-27	(3)	1-5	(<1)
Iron or steel	<1		1	0-2	5	<1-25	<1		<1
Rubber	15	0-50	12	0-25	2	0-5	3	1-4	

Table 27. RESULTS OF REPLICATE ANALYSES OF BIRMINGHAM FILTERS

Site	West End		North Birmingham									Downtown			
Date	14 Oct. 1974		9 Aug. 1974		14 Oct. 1974		26 Oct. 1974		Nov. 1, 1974			27 Aug. 1974		1 Nov. 1974	
TSP ($\mu g/m^3$)	103		123		227		351		236			123		112	
Laboratory	A	A	A	A	A	A	A	B	A	B	B	A	B	A	A
Analysis	1	2	1	2	1	2	1	1	1	1	2	1	1	1	2
Components															
Minerals	(82)	(86)	(80)	(86)	(66)	(60)	(65)	(5)	(75)	(30)	(26)	(83)	(6)	(43)	(69)
Quartz	25	12	25	30	20	25	25		35			8		8	30
Calcite	45	40	52	21	31	23	29		30			30		30	32
Feldspars		4													
Hematite	10	30	3	35	15	12	8		10			45		5	7
Mica	2	<1													
Other							3								
Combustion Products	(6)	(14)	(15)	(13)	(34)	(35)	(32)	(95)	(19)	(70)	(74)	(13)	(94)	(2)	(26)
Soot:															
Oil		5				8		5		5	28				
Coal		4	4	4		16	32								
Soot	5				33				19			11		2	26
Glassy fly ash	1	5	9	9	1	11		90	tr	65	46	2			
Incinerator fly ash		<1													
Burned wood															
Burned paper		<1													
Magnetite															
Biological Material	(2)	(<1)	(<1)	(<1)	(<1)	(2)	(<1)	(<1)	(5)	(<1)	(<1)	(<1)	(<1)	(5)	(<1)
Pollen	<1	<1			<1							tr		tr	
Spores	<1	<1			<1				tr					tr	tr
Paper	<1	<1		<1	<1									tr	<1
Starch	tr		tr	<1	<1	tr	<1					tr		<1	
Misc. plant tissue	2	<1			<1	2	<1		5					5	<1
Miscellaneous	(10)	(<1)	(5)	(1)	(<1)	(3)	(3)	(<1)	(1)	(<1)	(<1)	(4)	(<1)	(50)	(5)
Iron or steel	<1	<1	<1	<1	<1	3	3		1			3			<1
Rubber	9		5	1								1		50	5

Table 28a. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1970)

Date	2 January 1970			9 March 1970			23 June 1970			4 July 1970			5 December 1970		
TSP ($\mu g/m^3$)	142			156			134			629			216		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(2)			(9)	1-60	8	(8)	1-60	6	(9-)	1-60	7	(1)	2-24	5
Quartz	1	2-60	20	3			2+			3-			1-		
Calcite	1	1-50	15	3			4			2					
Feldspars															
Hematite	1-	1-30	5	3			1			4					
Mica															
Combustion Products	(1+)			(1)	<1-20	1	(2)	<1-30	8	(1)	<1-65	2	(9)	<1-48	<1
Soot:															
Oil										} 1					
Coal				1											
V.fine soot							1						9		
Glassy fly ash															
Incinerator fly ash	1	1-75	25												
Burned wood															
Burned paper															
Magnetite															
Other							1								
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(7-)			(0+)			(0+)			(0+)			(0+)		
Iron or steel															
Rubber	7-	10-150	50												

Table 28b. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1971)

Date	11 April 1971			4 May 1971			21 May 1971			1 July 1971		
TSP ($\mu g/m^3$)	100			165			255			105		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size μm	Quantity, tenths	Size range, μm	Avg. size μm
Minerals	(4+)	<1-40	2	(7+)	<1-45	9	(8)	<1-60	5	(6)		
Quartz	1			2			3			1+	5-65	30
Calcite	1			4+			2			2+	2-75	15
Feldspars										1	4-60	20
Hematite	2+			1			1-			1	1-50	10
Mica												
Other							2+					
Combustion Products	(0+)			(2+)	<1-66	<1	(1)	2-52	6	(4-)		
Soot:												
Oil										1	5-50	20
Coal										1	1-80	25
Soot				2+			1					
Glassy fly ash										1	5-25	15
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite										1-	10-40	20
Biological Material	(5+)	20-50	38	(0+)			(0+)			(0+)		
Pollen												
Spores	5+											
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(0+)			(0+)			(1)	6-50	9	(1-)		
Iron or steel												
Rubber							1-			1-		

Table 28c. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1972)

Date	10 January 1972			2 June 1972			8 July 1972			17 November 1972		
TSP ($\mu g/m^3$)	35			297.			86			164		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7)			(8)	<1-12	2	(7)	<1-18	2	(7-)	1-45	7
Quartz	2	10-60	15	3			4			2		
Calcite	2	2-50	20	4+			2			3+		
Feldspars										1-		
Hematite	3	1-70	15				1					
Mica												
Clay												
Combustion Products	(2)		•	(2)	<1-4	1	(3-)			(2+)	<1-75	2
Soot:												
Oil	1	5-50	25									
Coal	1-	5-60	20	2			1-					
Soot										2+		
Glassy fly ash	1-	5-25	10				2					
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(0+)			(0+)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(1)			(0+)			(0+)			(1)	8-90	25
Iron or steel												
Rubber	1	10-80	30							1		

Table 28d. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1973)

Date	4 January 1973			21 February 1973			25 September 1973			19 October 1973		
TSP ($\mu g/m^3$)	143			172			116			225		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(5)			(8+)			(7+)	<1-45	5	(3+)	1-39	5
Quartz	2	10-70	30	4			3+			1		
Calcite	2	5-50	25	4			3			2		
Feldspars	1	2-60	20	1-								
Hematite							1-			1	1-16	
Mica												
Clay							1-					
Combustion Products	(4-)			(1+)	<1-10	1	(2)	<1-65	20	(6+)	<1-25	5
Soot:												
Oil	1+											
Coal				1+								
Soot	1-	<1-2	1							5		
Glassy fly ash	1-	5-25	15				1-					
Incinerator fly ash	1											
Burned wood										} 1		
Burned paper												
Magnetite												
Other							1					
Biological Material	(0+)			(0+)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(1+)			(0+)			(1-)	<1-165	30	(0+)		
Iron or steel												
Rubber	1+						1-					

Table 28e. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1974)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP ($\mu g/m^3$)	93			65			98			104			190			92		
Components	Quan-tity, tenths	Size range, µm	Avg. size, µm	Quan-tity, tenths	Size range, µm	Avg. size, µm	Quan-tity, tenths	Size range, µm	Avg. size, µm	Quan-tity, tenths	Size range, µm	Avg. size, µm	Quan-tity, tenths	Size range, µm	Avg. size, µm	Quan-tity, tenths	Size range, µm	Avg. size, µm
Minerals	(4)	1-34	6	(9+)	<1-36		(9+)	<1-20	5	(5)	1-40	15	(1+)	<1-15	1	(9)		
Quartz	2			8			1-			2-			1-			1		
Calcite	1-			1			2+			2			1-			7+		
Feldspars																		
Hematite	1+						7			1			1-					
Mica																		
Combustion Products	(3)	<1-60	6	(0+)			(1-)			(3+)			(9-)			(0+)		
Soot:																		
Oil																		
Coal	1																	
Soot																		
Glassy fly ash	2						1-			2	<1-40	3	9-					
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Other										1+	1-30	4						
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(3)	7-60	35	(1-)			(0+)			(2-)			(0+)			(1-)	15-100	45
Iron or steel										(1+)	20-150	35						
Rubber	3			1-												1-		

Table 29. COMPOSITE SUMMARY OF FILTER ANALYSES FOR NASN SITES IN BIRMINGHAM AND VICINITY (BY YEAR)

Year	1970		1971		1972		1973		1974	
No. of filters	5		4		4		4		6	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(57)	10-90	(64)	43-80	(73)	66-80	(61)	35-86	(63)	13-95
Quartz	19	5-30	19	8-30	30	22-38	26	8-40	23	4-79
Calcite	20	3-40	24	10-45	30	20-45	27	18-40	23	4-75
Feldspars			3	0-10	2	0-5	3	0-10		
Hematite	18	2-40	12	7-25	11	1-30	4	1-9	17	2-68
Mica										
Other	<1	0-1	6	0-25			1	0-5		
Combustion Products	(29)	10-89	(18)	2-36	(22)	18-26	(33)	15-63	(27)	3-87
Soot:										
Oil	1	0-5	3	0-12	2	0-8	4	0-15		
Coal	1	0-5	3	0-12	2	0-5			2	0-10
Soot	22	[illegible]-89	8	0-23	10	0-20	18	1-52	15	0-86
Glassy fly ash	1	0-[illegible]	3	<1-8	8	0-22	4	1-5	8	1-20
Incinerator fly ash	2	0-8					2	0-10		
Burned wood							2	0-10		
Burned paper									2	0-15
Magnetite										
Other	2	0-10	1	0-4			3	0-12		
Biological Material	(1)	<1-2	(14)	<1-53	(<1)	(0-1)	(1)	<1-2	(1)	0-3
Pollen	<1	-	13	0-53	<1		<1		<1	
Spores			<1				<1		<1	
Paper	<1		<1		<1		<1	0-2		
Starch	<1		<1		<1		<1		<1	
Misc. plant tissue	1	0-2	1	0-1	<1		1	0-2	1	0-3
Miscellaneous	(13)	0-66	(4)	0-9	(5)	0-10	(5)	0-15	(9)	0-30
Iron or steel	<1	0-1	<1		<1		<1		<1	
Rubber	13	0-66	4	0-9	5	0-10	5	0-15	9	0-30

Table 30. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN BIRMINGHAM

No. of filters	22^a	
	Quantity, percent	
Components	Average	Range
Minerals	(66)	14-90
Quartz	25	8-67
Calcite	24	3-52
Feldspars	<1	0-4
Hematite	17	3-65
Mica	<1	0-2
Other	<1	0-3
Combustion Products	(22)	2-86
Soot:		
Oil	4	0-86
Coal	2	0-10
Misc. soot	12	0-71
Glassy fly ash	3	0-20
Incinerator fly ash	<1	
Burned wood		
Burned paper	<1	
Magnetite		
Carbon black		
Other	1	0-15
Biological Material	(2)	0-8
Pollen	<1	
Spores	<1	
Paper	<1	
Starch	<1	
Misc. plant tissue	2	0-8
Leaf trichomes		
Miscellaneous	(10)	0-50
Iron or steel	2	0-25
Rubber	8	0-50
Other		

[a] Excludes filter analyses of NASN site samples.

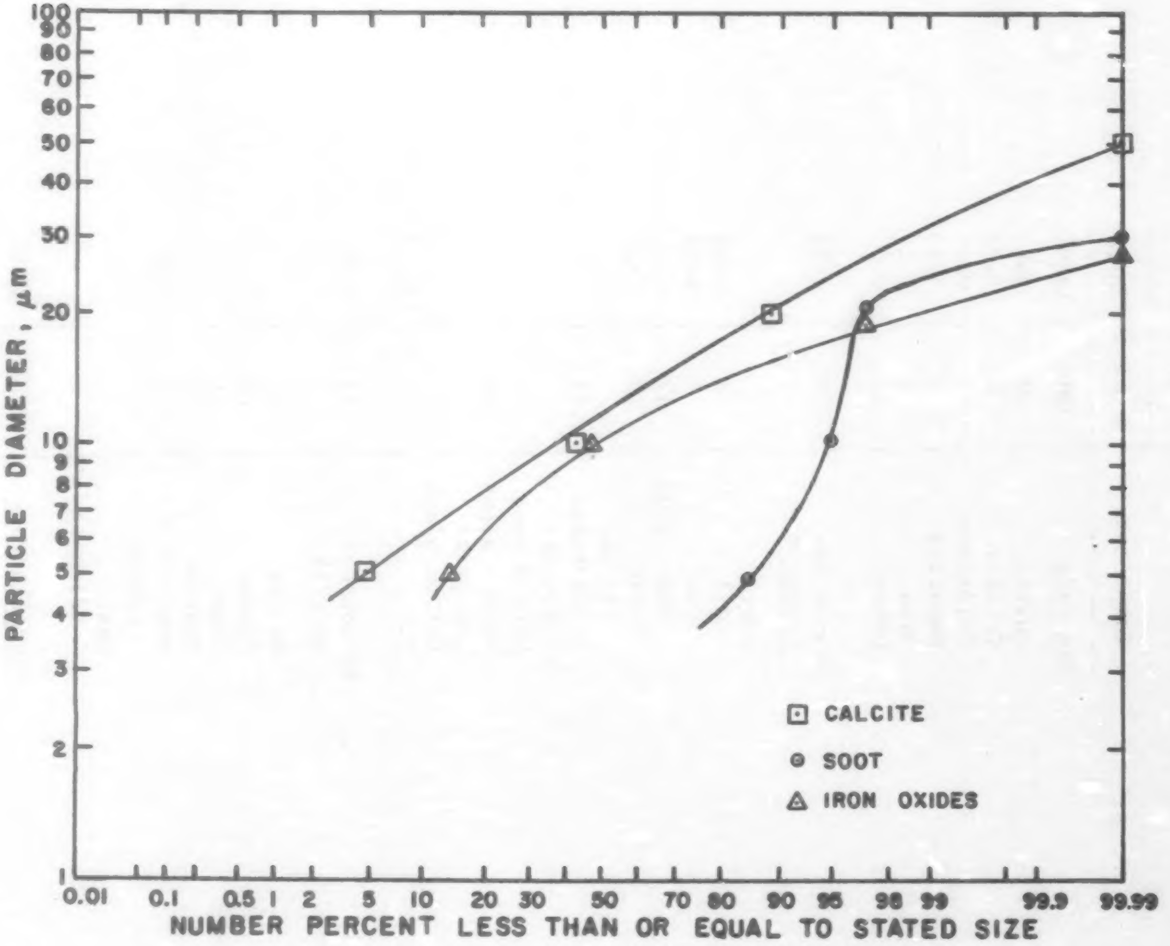

Figure 6. Cumulative size distributions for three particle types, Downtown site, Birmingham, October 14, 1974

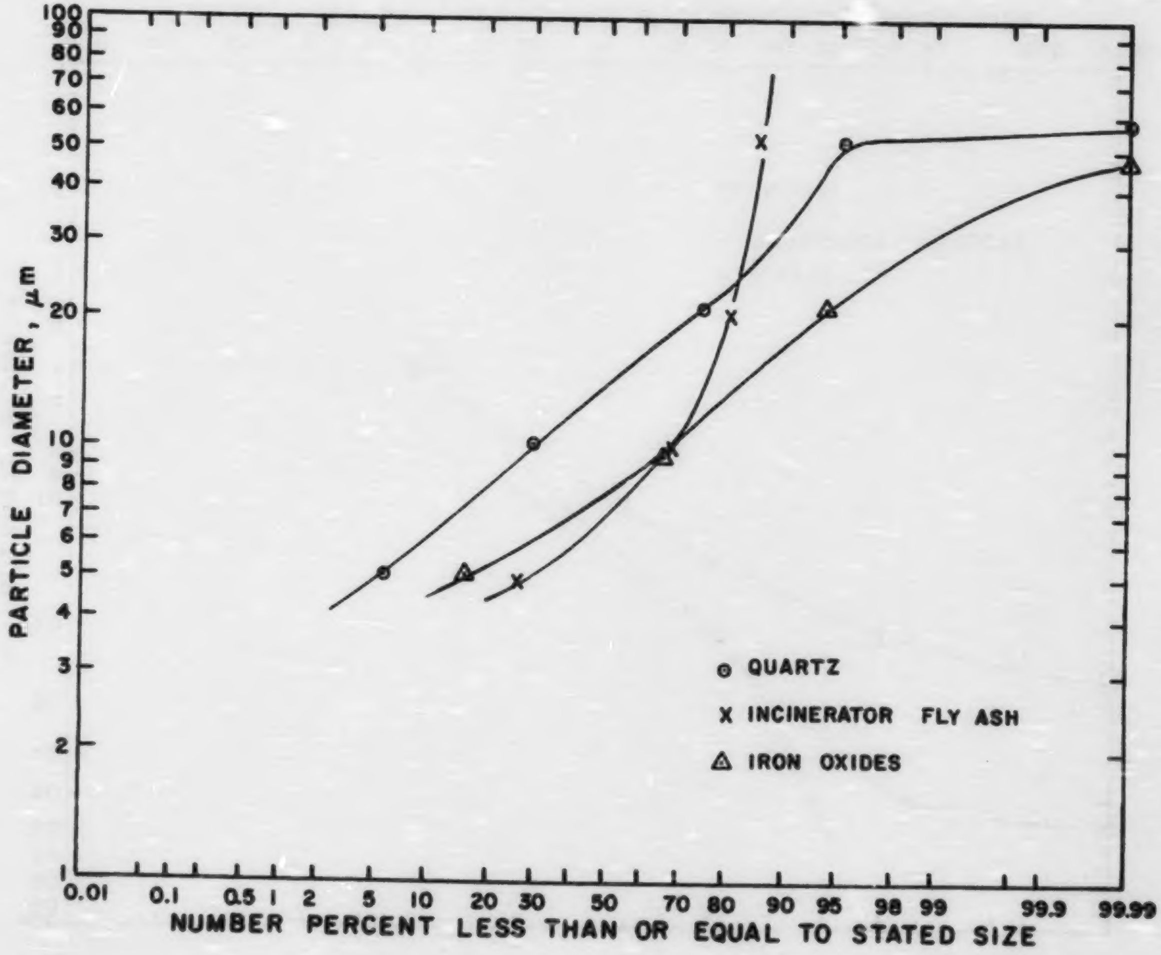

Figure 7. Cumulative size distributions for three particle types, North Birmingham site, Birmingham, October 26, 1974

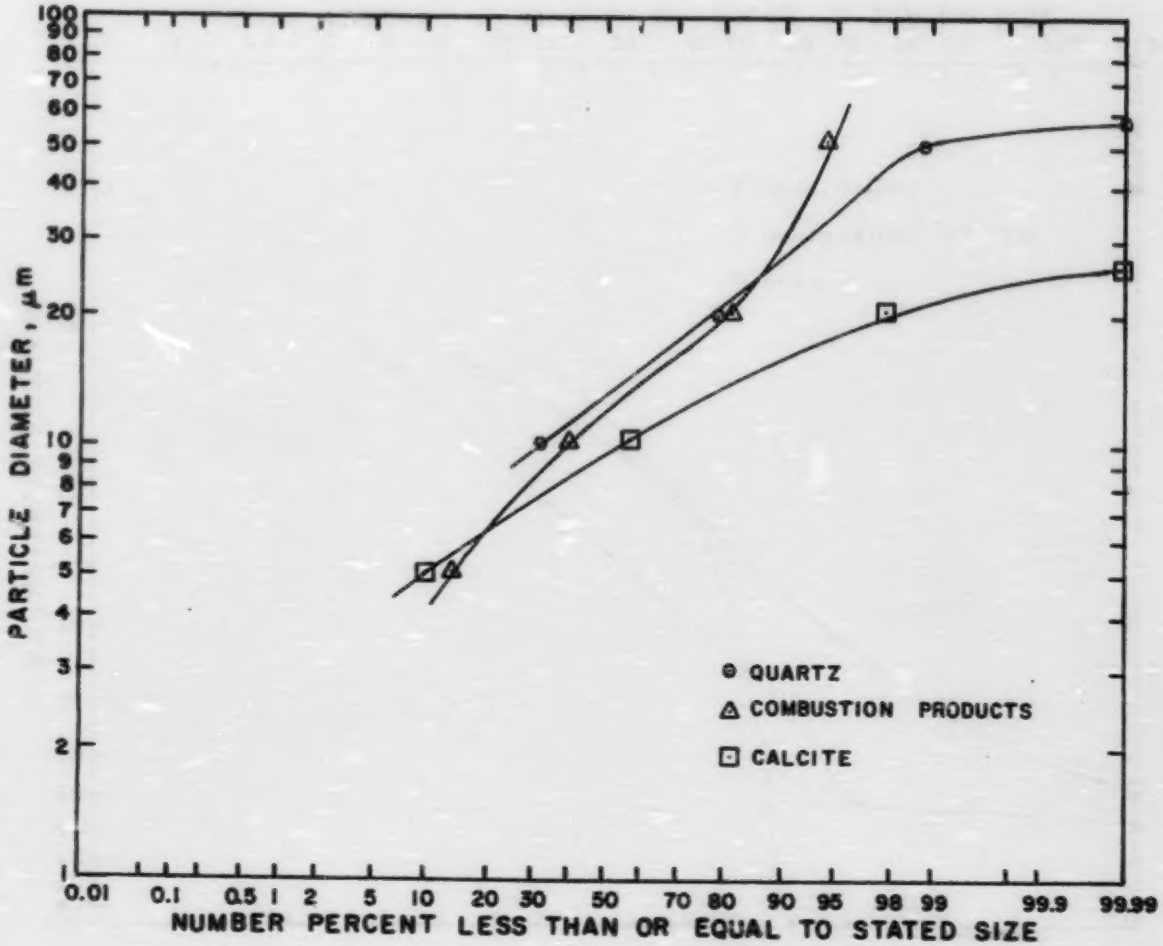

Figure 8. Cumulative size distributions for three particle types, North Birmingham site, Birmingham, November 1, 1974

Table 31. DETAILED PHYSICAL EXAMINATION: DOWNTOWN, BIRMINGHAM, OCTOBER 14, 1974

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a. Quartz confirmed by dispersion staining and (-) uniaxial interference figure. EDXRA shows only silicon and trace of iron (from hematite).

b. Oil soot confirmed (as far as possible, due to small particle size and variability of fly ash due to operating conditions) by brittleness, morphology and especially EDXRA analysis showing: aluminum, silicon (both from clay - feldspar impurities), calcium, sulfur, chlorine (these as normal constituents of oil soots), iron and vanadium (normal constituents of oils). The major constituent was carbon.

c. This sample was found to contain some rubber which was not reported in the original report. Confirmed as by its elastomeric nature, surface appearance and aluminum, silicon (all probably from road wear products), sulfur, chlorine, iron, titanium and zinc.

BALTIMORE

The Baltimore AQCR lies in the central portion of the State of Maryland along the western edge of the northern section of Chesapeake Bay. The important features of the AQCR are the Bay, the generally flat, low eastern portion, and the rolling hills and somewhat higher elevations of the western portion. The region lies near the path of low pressure systems which move across the country, resulting in changeable winds and weather in the region. During the summer, the region is influenced by the circulation of air masses over the area from the Deep South. Precipitation occurs frequently and moderately, averaging about 40 inches per year. Temperatures are moderated by the proximity to the Bay. High relative humidites are caused by the inflow of southerly winds and the proximity of the Bay. The region frequently experiences short-term inversions.

There is a high level and a wide variety of heavy industrial activity, much of which is concentrated along the Patapsco River. An extensive program of urban renewal and highway construction is being conducted. The reader is directed to Volume V of this report for a complete discussion of the subject city.

Of the 29 monitors recording TSP in the AQCR in 1974, nine sites exceeded the national annual primary standard of 75 $\mu g/m^3$, and five other sites exceeded only the annual secondary standard of 60 $\mu g/m^3$. Out of a total of 2,025 days of sampling, the 24-hour secondary standard was exceeded on 154 days (7.6 percent) and the primary standard was exceeded on 18 days (0.9 percent). Only eight of the 29 stations did not exceed either 24-hour standard during the year. All but two of the nine sites exceeding the annual primary standard are located in Baltimore City.

The locations of the eight sites that were selected for filter analysis in Baltimore are shown in Figure 9. Table 32 details the pertinent characteristics of these sites, and Table 33 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 34. The results of each of the 27 filters submitted for routine analysis are presented in Table 35. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 36. Seven filters underwent replicate analyses, and the results of this task are presented in Table 37.

Baltimore was one of three study cities selected for particulate trends analysis. To accomplish this task, two to four filters for each of the calendar years 1964, 1970, 1971, 1973 and 1974 were selected from the NASN sampling site for microscopic analysis. The results of each filter analysis are presented in Table 38 and a composite summary for each year is presented in Table 39. Several changes in the makeup of the particulate have apparently taken place, especially between 1964 and 1970 although the number of samples is limited. During that interval the percent contribution by combustion products decreased by more than a factor of two. This decrease, from 47 percent to 22 percent of the observed particulate, was matched, however, by an equally impressive increase in the percent contribution by minerals. Of course when describing the amount of material in percents, a decrease in one constituent must be matched by an increase in another constituent(s) because the total must equal 100 percent. However, if the microscopy results are a reliable indication of the makeup of all the particulate collected on the hi-vol filters, then the weighted average concentration of combustion products on the filters analyzed dropped from 94 $\mu g/m^3$ in 1964 to 44 $\mu g/m^3$ in 1970. The corresponding increase in minerals was from 154 $\mu g/m^3$ in 1964 to 192 $\mu g/m^3$ in 1970.

The makeup of the particulate at the NASN site since 1970 has shown year to year fluctuations, but a continued downward trend in combustion products is indicated. This decrease in the combustion products apparently has not been accompanied by an increase in the percent minerals. The amount of rubber detected on filter samples from this site, however, has risen sharply. In the two most recent years of record rubber accounted for nearly 15 percent of the particulate at the NASN site. This is in sharp contrast to the composite results of analyses of non-NASN sites in Baltimore for 1974, as shown in Table 40. A citywide average rubber content of only 2 percent is indicated, which is as low as any of the 14 study cities. Interestingly, the non-NASN site with the highest reported levels of rubber was Site 7 which is located on the same roof as the NASN hi-vol. The average rubber content for the four filters analyzed from that site was 7 percent, but ranged as high as 26 percent on August 27, 1974. That was also a NASN sampling day and a sample of the NASN filter was also analyzed microscopically. The results, compiled by two separate analysts, compare reasonably well, especially for the percent combustion products. Oddly, the NASN sample was reported to have less rubber than the sample from the local agency site.

The total amount of mineral material reported at the NASN site for 1974 is in excellent agreement with the composite shown in Table 40 for the non-NASN sites. Even the individual constituents of quartz, calcite, feldspars and hematite are in good agreement. The amount of mineral material reported for Baltimore is very typical of the other study cities, ranking sixth highest. In terms of combustion products, Baltimore is seventh out of the 14 study sites and so is quite typical in that respect as well.

One of the filters that had undergone routine optical microscopic analysis was also submitted for detailed physical examination. The results of this task are presented in Table 41. The Maryland Bureau of Air Quality Control takes portions of hi-vol filters and runs chemical analyses on the monthly composite samples. The results of analyses for lead and benzo(a) pyrene are presented in Tables 42 and 43 respectively for six Baltimore City sites.

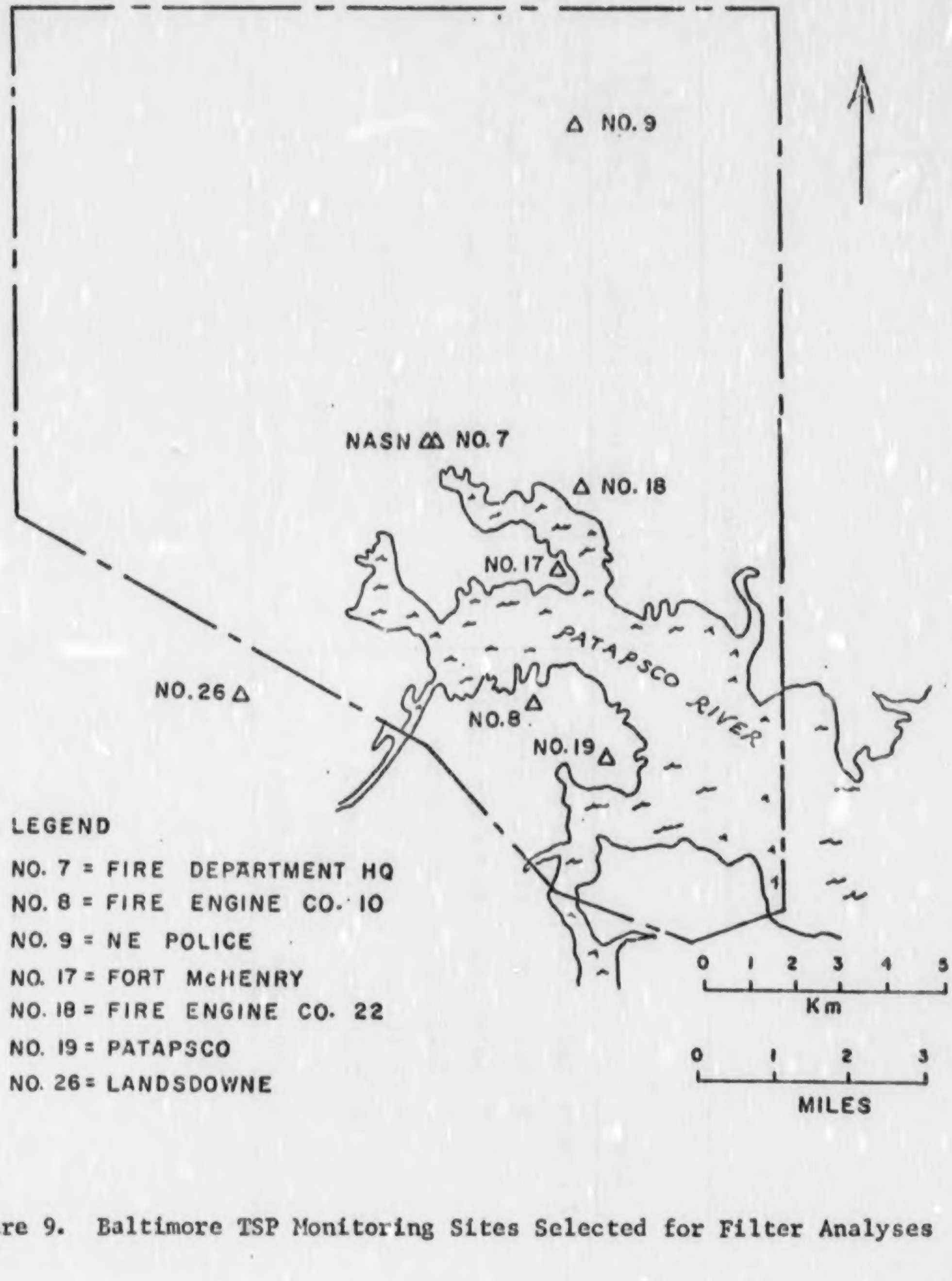

△ NO. 9
NASN △△ NO. 7
△ NO. 18
NO. 17 △
PATAPSCO RIVER
NO. 26 △
NO. 8 △
NO. 19 △
LEGEND
NO. 7 = FIRE DEPARTMENT HQ
NO. 8 = FIRE ENGINE CO. 10
NO. 9 = NE POLICE
NO. 17 = FORT McHENRY
NO. 18 = FIRE ENGINE CO. 22
NO. 19 = PATAPSCO
NO. 26 = LANDSDOWNE
0 1 2 3 4 5
Km
0 1 2 3
MILES

Figure 9. Baltimore TSP Monitoring Sites Selected for Filter Analyses

Table 32. SAMPLING SITE CHARACTERISTICS

Code	Town	Address	Height (feet)	Site characteristics	1974 Geometric mean TSP
7 & NASN	Baltimore	Fire Dept. HQ	30	Center City	105
8	Baltimore	Fire Company #10	30	Commercial-Industrial	134
9	Baltimore	NE Police Station	20	Suburban-Residential	53
17	Baltimore	Fort McHenry	50	Industrial	102
18	Baltimore	Fire Company #22	30	Suburban-Residential	95
19	Baltimore	Patapsco Sewage Plant	15	Commercial-Industrial	112
26	Lansdowne	High School	25	Suburban-Residential	62

Table 33. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (FRIENDSHIP INTERNATIONAL AIRPORT, BALTIMORE)

	Precipitation, in.		Wind speed, mph		Wind direction, deg	
Date	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
7/19/64						
10/07/64						
10/27/64						
4/09/70	0.01	0	12.7	10.4	250, 240, 240, 230 200, 290, 290, 300	250
5/27/70	0	0.03	11.2	10.1	290, 290, 310, 280 290, 330, 350, 350	310
7/04/70	0.42	0	7.1	4.4	200, 200, 240, 270 200, 140, 330, 240	230
8/14/70	t	0	6.6	2.8	260, C, 210, 160 340, 180, 260, 310	280
1/29/71	t	t	8.3	7.6	260, 170, 160, 210 220, 210, 190, 180	200
2/11/71	0	0	4.8	4.6	C, C, C, 170 130, 140, 160, 170	150
5/04/71	0	0	15.5	15.3	270, 260, 270, 290 270, 280, 280, 250	270
3/29/73	0	0	4.8	4.0	80, C, 70, 60 120, 120, 170, 100	100
7/27/73	0	0.02	9.2	7.8	190, 210, 250, 230 260, 280, 200, 190	230
9/01/73	0	0	4.2	3.7	C, 250, C, 240 360, 260, 240, 260	250

Table 33 (continued). METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (FRIENDSHIP INTERNATIONAL AIRPORT, BALTIMORE)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
1/05/74	0	0.15	4.5	2.2	290, 350, 360, 70 70, 140, C, C	30
1/17/74	0	0	8.9	7.8	280, 20, 350, 360 10, 30, 40, 60	10
2/12/74	0	t	6.5	5.0	190, 250, 260, 270 270, 240, 140, C	250
2/28/74	t	0	8.5	7.0	190, C, C, 200 160, 220, 260, 180	210
8/15/74	0	0.12	6.9	4.3	270, 40, 20, 60 80, 100, 140, 340	60
8/27/74	0	1.73	5.3	4.8	210, 230, C, 150 220, 210, 180, 180	200
9/17/74	t	0	5.6	4.5	C, 60, 160, 200 190, 210, 200, 180	190
9/26/74	0	0	6.8	6.1	250, 280, 260, 270 270, 270, 170, 250	260

Note: C = Calm
t = Trace

Table 34. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE BALTIMORE, MARYLAND, NASN SITE NO. 210120001 (μg/m^3)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	16.52	15.07	3.05	2.59
1973	12.71	11.69	3.17	2.87
1974	11.43	10.26	3.69	3.35

Table 35a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (FIRE DEPT. HQ. — NO. 7)

Date	12 February 1974			28 February 1974			27 August 1974			17 September 1974		
TSP (μg/m^3)	237			198			NA[a]			171		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7+)			(8)	<1-60	11	(5+)	1-67	7	(8)		
Quartz	3	<1-100	2	4			3			4	<1-60	6
Calcite	2+	<1-100	2	3			2-			2+	<1-60	6
Feldspars	1-									1-		
Hematite	1+	<1-20	0.5	1-			1-			1	<1-30	0.5
Mica												
Combustion Products	(2)			(1)	<1-30	4	(2)	<1-12	5	(2)		
Soot:												
Oil	1+	<1-200	0.5							1		
Coal	1-									1-		
Soot				1			1-					
Glassy fly ash							1+					
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(0+)			(1-)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(1-)			(1-)			(3-)	10-250	50	(0+)		
Iron or steel												
Rubber	1-						3-					

[a] Not Available

Table 35b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (FORT McHENRY — NO. 17)

Date	5 January 1974			17 January 1974			28 February 1974			15 August 1974			27 August 1974			26 September 1974		
TSP (μg/m³)	90			118			197			99			74			NA[a]		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8)			(8+)			(4-)	<1-21	7	(8+)			(6)	<1-33	1	(5)	<1-75	8
Quartz	3+	<1-70	5	3	<1-50	5	1+			3-	<1-100	5	1			3		
Calcite	2	<1-100	5	3	<1-50	5	2-			1+	<1-50	5				1-		
Feldspars				1-	<1-30	5												
Hematite	2+	<1-30	0.5	2	<1-15	0.5	1-			4	<1-120	0.5				1+		
Mica																		
Clay													5-					
Combustion Products	(1+)			(1+)			(6)	<1-30	2	(1+)			(4-)	<1-34	18	(4-)	<1-65	15
Soot:																		
Oil	1	<1-400	0.5	1	<1-80	0.5				1	<1-180	0.5				2+		
Coal										1-			2					
Soot							5						1					
Glassy fly ash							1											
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Glass																1		
Biological Material	(1-)			(0+)			(1-)	3-14	12	(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch	1-						1-											
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(1)	5-100	50
Iron or steel																1		
Rubber																		

[a] Not Available

Table 35c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (N.E. POLICE— NO. 9, FIRE ENGINE CO. 10— NO. 8, AND PATAPSCO— NO. 19)

Site	N. E. Police — No. 9									Fire Engine Co. 10 — No. 8						Patapsco — No. 19		
Date	12 February 1974			28 February 1974			17 September 1974			28 February 1974			26 September 1974			28 February 1974		
TSP ($\mu g/m^3$)	114			116			92			168			245			164		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(4)			(3+)	<1-15	12	(8)			(8+)	<1-65	10	(9)			(7+)	<1-65	10
Quartz	1+	<1-50	2	1			3	<1-50	2	4			2	<1-45	5	2+		
Calcite	1+	<1-50	2	1			2+	<1-50	2	4			3	<1-40	5	2		
Feldspars	1-												1-	<1-100	5	1+		
Hematite	1-	<1-30	0.5	1+			2+	<1-30	0.5	1-			3	<1-150	0.5	1-		
Mica																		
Combustion Products	(6)			(6)	<1-32	2	(2)			(1)	<1-70	1	(1)			(2-)	1-85	
Soot:																		
Oil	6	<1-500	0.5				1	<1-100	0.5				1-	<1-200	0.5	1-		
Coal				5			1-						1-	<1-50	3			
Carbon black soot										1						1		
Glassy fly ash				1-			1-											
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(1-)	4-105	20	(0+)			(0+)			(0+)			(1)	4-60	30
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue				1-												1		
Miscellaneous	(0+)			(0+)			(0+)			(1-)			(0+)			(0+)		
Iron or steel																		
Rubber										1-								

Table 35d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (FIRE ENGINE CO. 22 — NO. 18)

Date	5 January 1974			17 January 1974			28 February 1974			15 August 1974			27 August 1974		
TSP ($\mu g/m^3$)	86			72			265			119			84		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8)			(9)			(7-)	2-60	9	(8+)			(7+)	2-105	13
Quartz	3	<1-50	5	5	<1-100	5	4+			2+	<1-70	5	4+		
Calcite	1+	<1-40	5	2	<1-80	5	2			1+	<1-75	5	1		
Feldspars										1-					
Hematite	3+	<1-50	0.5	1+	<1-50	0.5	1-			4	<1-100	0.5	2		
Mica															
Combustion Products	(2)			(1)			(2)	1-99	3	(2-)			(1+)	1-50	6
Soot:															
Oil	1	<1-200	0.5	1-	<1-250	0.5				1					
Coal	1-						1+			1-					
Mixed coal and oil													1-		
Glassy fly ash							1-						1		
Incinerator fly ash															
Burned wood															
Burned paper															
Magnetite															
Biological Material	(0+)			(0+)			(1)	4-24	15	(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch							1								
Misc. plant tissue															
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(1)	10-122	41
Iron or steel															
Rubber													1		

Table 35e. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY (LANSDOWNE — NO. 26)

Date	5 January 1974			17 January 1975			28 February 1974			15 August 1974			27 August 1974			26 September 1974		
TSP ($\mu g/m^3$)	77			83			NA[a]			85			NA[a]			NA[a]		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8+)			(9-)			(7)			(5)			(4+)	<1-66)	10	(5)	1-60	9
Quartz	4+	<1-75	5	3+	<1-75	5	6+	1-78	12	2	<1-14	1.5	4			4		
Calcite	2	<1-50	5	4	<1-70	5				1-	<1-30	4	1-			1		
Feldspars										1-	<1-16	4						
Hematite	1+	<1-25	0.5	1	<1-30	0.5				2	<1-8	4						
Mica																		
Combustion Products	(1)			(1+)			(1+)	<1-60	2	(4+)			(5)	<1-30	5	(5)	<1-30	6
Soot:																		
Oil	1	<1-80	0.5	1	<1-200	0.5				3	<1-3	<0.5						
Coal										1	<1-3	<0.5						
Soot							1						1			1		
Glassy fly ash										1-	<1-3		4			4		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(1-)			(0+)			(1-)	6-150	35	(1-)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch	1-	3-25	12															
Misc. plant tissue							1-											
Miscellaneous	(0+)			(0+)			(1)	5-60	24	(0+)			(1-)			(0+)		
Iron or steel																		
Rubber							1						1					

[a] Not Available

Table 36. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN BALTIMORE AND VICINITY

Site	Lansdowne No. 26		Ft. McHenry No. 17		Fire Engine Co. 22 – No. 18		Fire Dept. HQ No. 7		N. E. Police No. 9		Fire Engine Co. 10 – No. 8		Patapsco No. 19
No. of filters	6		6		5		4		3		2		1
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	—
Minerals	(64)	45-87	(66)	37-85	(79)	66-88	(73)	53-80	(52)	35-82	(86)	85-88	(74)
Quartz	40	20-65	24	10-35	38	25-50	36	30-40	19	12-30	30	20-40	25
Calcite	13	3-40	14	2-30	16	12-20	25	16-32	16	8-25	35	30-41	20
Feldspars	2	0-5	2	0-5	2	0-4	2	0-4	2	0-4	3	0-6	15
Hematite	9	2-20	18	2-40	23	5-40	9	5-15	15	5-25	17	4-30	4
Mica			<1		<1		<1	0-1			1	0-2	<1
Other			8	0-46									10
Combustion Products	(31)	13-50	(29)	13-58	(16)	11-20	(18)	12-21	(46)	18-61	(11)	11	(16)
Soot:													
Oil	9	0-30	9	0-25	5	0-10	6	0-15	23	0-60	2	0-5	4
Coal	2	0-10	5	0-22	5	0-14	4	0-8	19	1-52	3	0-5	
Soot	5	0-12	10	0-50			4	0-11			5	0-10	
Mixed coal and oil					1	0-5							
Glassy fly ash	15	1-42	3	0-8	5	0-10	4	1-15	4	<1-7	1	1	2
Incinerator fly ash							<1		<1				
Burned wood							<1						
Burned paper							<1						
Magnetite													10
Other			2	0-12									
Biological Material	(3)	<1-6	(3)	<1-5	(2)	<1-11	(1)	<1-4	(2)	<1-5	1	<1-1	(10)
Pollen	<1	<1-1	<1		<1				<1		<1		<1
Spores	1	0-3	<1		<1		<1		<1		<1		
Paper	<1		<1		<1		<1		<1				<1
Starch	1	0-3	3	0-5	1	0-8	<1	0-2	<1	0-1			<1
Misc. plant tissue	1	<1-4	<1		1	0-3	1	<1-2	2	0-4	1	<1-1	10
Miscellaneous	(2)	<1-10	(2)	0-10	(2)	<1-10	(8)	<1-26	<1	<1-1	(2)	<1-4	(<1)
Iron or steel	<1		2	0-10	<1	tr-1	1	0-3	<1		<1		<1
Rubber	2	0-10	<1	0-2	2	0-9	7	0-26	<1	0-1	2	0-4	

Table 37. RESULTS OF REPLICATE ANALYSES OF BALTIMORE FILTERS

Site	Fire Engine Co. 22 — No. 18														Lansdowne — No. 26				Fire Dept. Hq. No. 7	
Date	17 January 1974				28 February 1974					15 August 1974		27 August 1974			17 January 1974		28 February 1974		28 February 1974	
TSP (g/m^3)	72				265					119		84			83		NA[a]		198	
Laboratory	A	A	A	B	A	A	A	B	B	A	A	A	A	B	A	A	A	A	A	A
Analysis	1	2	3	1	1	2	3	1	2	1	2	1	2	1	1	2	1	2	1	2
Components																				
Minerals	(88)	(63)	(78)	(35)	(66)	(79)	(78)	(50)	(53)	(84)	(78)	(75)	(77)	(24)	(87)	(87)	(70)	(66)	(78)	(65)
Quartz	50	30	25		43	30	25			25	10	43	50		35	25	65	23	40	25
Calcite	20	25	25		18	35	25			15	30	12	15		40	50	3	30	32	22
Feldspars	3	3	3			4	3			4	3		2		2	2		3		3
Hematite	15	5	25		5	10	25			40	35	20	10		10	10	2	10	6	15
Mica	<1																		tr	<1
Combustion Products	(11)	(7)	(10)	(63)	(20)	(15)	(10)	(48)	(42)	(16)	(16)	(15)	(15)	(73)	(13)	(13)	(15)	(26)	(12)	(9)
Soot:																				
Oil	6	5	4	6	14	10	4	7	2	10	10		10	24	10	10		6		
Coal	2	1	4			2	4			5	4		4		2	2		8		
Soot												5					11		11	6
Glassy fly ash	3	1	2	57	6	2	2	41	40	1	2	10	1	49	1	1	4	10	1	1
Incinerator fly ash	<1		<1			1				<1	<1							2		
Burned wood	<1									<1								<1	tr	2
Burned paper	<1		<1				<1			<1	<1		<1			<1		<1		
Magnetite																				
Biological Material	(1)	(<1)	(6)	(2)	(11)	(1)	(6)	(2)	(5)	(<1)	(<1)	(<1)	(<1)	(1)	(<1)	(<1)	(5)	(<1)	(4)	(1)
Pollen	<1	<1			tr	<1				<1		<1			<1		1		tr	<1
Spores	<1	<1	<1		tr	<1	<1			<1	<1		<1		<1	<1		<1		<1
Paper	<1	<1	<1		tr	<1	<1			<1	<1		<1		<1	<1	tr	<1		<1
Starch	1	<1	6	2	8	1	6	2	5	<1		<1	<1				tr	<1	2	1
Misc. plant tissue	<1	<1	<1		3	<1	<1			<1	<1		<1		<1	<1	4	<1	2	<1
Miscellaneous	(<1)	(30)	(6)	(<1)	(3)	(5)	(6)	(<1)	(<1)	(<1)	(6)	(10)	(8)	(2)	(<1)	(<1)	(10)	(8)	(6)	(25)
Iron or steel	<1	<1	<1		tr	<1	<1			<1	<1	1	<1		<1	<1	tr	<1	3	<1
Rubber		30	6		3	5	6			<1	6	9	8				10	8	3	25

[a] Not Available

Table 38a. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 210120001 IN BALTIMORE (1964 AND 1970)

Date	19 July 1964			7 October 1964			27 October 1964			9 April 1970			27 May 1970			4 July 1970		
TSP ($\mu g/m^3$)	177			140			435			149			109			468		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(6)	1-30	15	(2+)	<1-60	15	(7+)	<1-60	5	(8+)	1-83	17	(6-)	1-100	7	(3+)	3-60	7
Quartz	5			1			4			6			4+			4+		
Calcite				1-			1-			1								
Feldspars	1-									1								
Hematite				1			3			1-			1-			3+		
Mica																		
Coal													1-					
Combustion Products	(4)	<1-150	10	(7+)	<1-100	2	(2+)	<1-45	10	(2-)	<1-120	<1	(4)	<1-105	4	(2-)	3-240	9
Soot:																		
Oil	2+			7+														
Coal	1-																	
Soot							2			1			2+			1		
Glassy fly ash	1-									1-			1-			1-		
Incinerator fly ash																		
Burned wood							1-											
Burned paper																		
Magnetite																		
Shaly particles													1					
Biological Material	(0+)			(0+)			(0+)			(0+)			(1-)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber																		

Table 38b. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 21012001 IN BALTIMORE (1970, 1971, AND 1973)

Date	14 August 1970			29 January 1971			11 February 1971			4 May 1971			29 March 1973			27 July 1973		
TSP (µg/m³)	227			266			143			89			149			80		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(8+)	<1-105	4	(5)			(6+)			(8-)	<1-80	12	(7+)			(7+)		
Quartz	6+			2	<1-100	5	3+	<1-100	8	2-			3	<1-100	5	3	<1-60	5
Calcite	1			1+	<1-60	5	1	<1-50	5	3			3	<1-60	5	3	<1-60	5
Feldspars										1-						1-		
Hematite				1-						1+			1	<1-40	0.5	1	<1-30	0.5
Mica	1			1	<1-60	0.5	1+	<1-40	0.5	1								
Combustion Products	(1+)			(4)			(4-)			(1+)	<1-16	3	(1)			(1)		
Soot:																		
Oil				3+	<1-200	0.5	2+	<1-200					1	<1-120	0.5	1-	<1-120	0.5
Coal																		
Fine soot	1									1								
Glassy fly ash				1-			1			1-								
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(1)			(0+)			(1-)	9-75	20	(1+)			(1+)		
Iron or steel																		
Rubber				1						1-			1+	<1-110	30	1+	<1-200	30

Table 38c. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 210120001 IN BALTIMORE (1973 AND 1974)

Date	1 September 1973			15 August 1974			27 August 1974		
TSP ($\mu g/m^3$)	112			102			69		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7+)			(8)			(6+)		
Quartz	3+	<1-100	5	3	<1-50	5	3	<1-60	
Calcite	2	<1-80	5	3	<1-50	5	2	<1-60	
Feldspars				1-			1-		
Hematite	1+	<1-100	0.5	1+	<1-40	0.5	1	<1-30	0.5
Mica									
Combustion Products	(1)			(1)			(2)		
Soot:									
Oil	1	<1-200	0.5	1-	<1-100	0.5	1+	<1-120	0.5
Coal									
Glassy fly ash							1-		
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Material	(0+)			(0+)			(0+)		
Pollen									
Spores									
Paper									
Starch									
Misc. plant tissue									
Miscellaneous	(1+)			(1)			(1+)		
Iron or steel									
Rubber	1+	<1-200	3	1	<1-120	30	1+	<1-120	30

Table 39. COMPOSITE SUMMARY OF FILTER ANALYSES FOR NASN SITES IN BALTIMORE AND VICINITY (BY YEAR)

Year	1964		1970		1971		1973		1974	
No. of filters	3		4		3		3		2	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(52)	25-74	(77)	56-85	(63)	49-77	(74)	73-75	(72)	64-79
Quartz	33	9-52	53	45-64	23	16-35	32	30-35	30	30
Calcite	4	1-7	6	0-12	19	10-32	27	20-30	25	20-30
Feldspars	2	0-5	2	0-8	4	3-4	3	3-4	4	4
Hematite	13	0-32	14	4-35	13	10-15	12	10-15	13	10-15
Mica	<1	0-1			4	0-10	<1	0-1		
Other			2	0-6						
Combustion Products	(47)	24-75	(22)	13-40	(31)	15-41	(11)	10-12	(15)	10-21
Soot:										
Oil	33	0-74			21	2-35	9	7-10	11	7-15
Coal	3	0-8			1	0-2	<1	0-1	1	1-2
Soot	7	0-22	16	12-25	3	0-9				
Glassy fly ash	3	<1-8	4	1-5	6	4-10	2	2	3	2-4
Incinerator fly ash										
Burned wood	2	0-5								
Burned paper										
Magnetite										
Other			2	0-10						
Biological Material	(1)	0-2	1	0-4	(<1)	<1-1	(<1)		(<1)	<1-1
Pollen			<1		<1		<1		<1	
Spores	<1		<1		<1		<1		<1	
Paper			<1	0-1	<1		<1		<1	
Starch	1	0-1	<1	0-1	<1		<1		<1	
Misc. plant tissue	<1	0-1			<1	<1-1	<1		<1	<1-1
Other			1	0-3						
Miscellaneous	(<1)		(<1)		(6)	<1-10	(15)	15	(13)	10-15
Iron or steel	<1		<1		<1		<1		<1	
Rubber					6	<1-10	15	15	13	10-15

Table 40. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN BALTIMORE

No. of filters	27[a]	
	Quantity, percent	
Components	Average	Range
Minerals	(69)	52-88
Quartz	31	10-50
Calcite	18	2-41
Feldspars	3	0-6
Hematite	15	2-46
Mica	<1	
Other	2	0-46
Combustion products	(25)	11-61
Soot:		
Oil	9	0-60
Coal	5	0-52
Misc. soot	4	0-50
Glassy fly ash	6	0-42
Incinerator fly ash	<1	
Burned wood	<1	
Burned paper	<1	
Magnetite		
Carbon black		
Other	1	0-12
Biological material	(3)	<1-11
Pollen	<1	
Spores	<1	
Paper	<1	
Starch	1	0-8
Misc. plant tissue	2	0-10
Leaf trichomer		
Miscellaneous	(3)	0-26
Iron or steel	1	0-10
Rubber	2	0-26
Other		

[a] Excludes filter analyses of NASN site samples

Table 41. DETAILED PHYSICAL EXAMINATION: FIRE ENGINE CO. 22, BALTIMORE, JANUARY 17, 1974

A. Quartz - confirmed by refractive indices and (+) uniaxial interference figure. EDXRA shows only silicon and traces of aluminum.

B. Calcite - Confirmed by refractive indices, and (-) uniaxial interference figure. Carbonate confirmed microchemically by evolution of CO_2 gas. EDXRA shows only calcium. Some samples show trace of magnesium indicating some particles are dolomite, $CaMg(CO_3)_2$.

C. Hematite - confirmed by high refractive indices, birefringence and deep red color. EDXRA shows only iron.

D. Oil soot - oil soot confirmed by brittleness, morphology of large pieces and EDXRA which showed aluminum, silicon, calcium, sulfur, iron and vanadium. The major constituent was carbon. The vanadium principally distinguishes this sample chemically from fine coal soot.

Table 42. MONTHLY COMPOSITE LEAD LEVELS IN BALTIMORE FOR 1974, $\mu g/m^3$

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Avg
Fire Dept. HQ	1.138	.576	.865	1.549	.670	.937	.840	1.259	1.314	1.149	1.410	1.415	1.094
Fire Dept. #10	.847	.356	.620	.942	1.181	.754	.732	-	1.157	2.350	-	1.130	1.007
Northeasc Police	.992	.152	.344	.865	.381	.879	.766	.876	.960	.554	1.918	1.152	.820
Northwest Police	.542	.622	.712	.966	.585	.668	.739	.943	1.492	1.031	2.030	1.101	.953
Southeast Police	1.533	.529	1.799	2.095	1.036	1.137	1.675	2.159	2.694	1.308	3.081	1.742	1.732
Southwest Police	1.255	.639	1.081	1.191	.709	.976	1.095	.912	1.519	1.005	1.835	1.765	1.165
Monthly Average	1.051	.474	.904	1.268	.760	.892	.975	1.230	1.523	1.233	2.055	1.384	-

Table 43. MONTHLY COMPOSITE BENZO(A) PYRENE LEVELS IN BALTIMORE FOR 1974, $\mu g/m^3$

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Avg
Fire Dept. HQ	4.49	3.29	4.06	-	.70	.62	1.10	.92	1.21	-	3.86	2.29	2.25
Fire Dept. #10	4.46	2.24	2.47	2.05	1.10	1.76	2.00	-	1.75	-	-	3.17	2.33
Northeast Police	4.13	2.12	2.60	1.13	.51	.57	1.05	1.90	1.10	-	3.81	1.96	2.01
Northwest Police	2.87	3.50	3.70	.81	1.35	.54	.70	1.05	1.00	-	4.23	2.10	1.99
Southeast Police	6.35	3.95	3.80	3.48	1.60	1.10	1.00	.86	.84	-	4.86	2.94	2.80
Southwest Police	5.59	5.33	3.00	2.43	1.10	.80	1.10	.32	1.14	-	3.52	3.19	2.50
Monthly Average	4.65	3.41	3.27	1.98	1.06	.70	1.16	1.01	1.17	-	4.06	2.61	-

PHILADELPHIA

The Metropolitan Philadelphia Interstate Air Quality Control Region (AQCR) lies along the Delaware River basin and encompasses 11 counties from three states and two EPA regions. While the major center of population in the area is Philadelphia, the fourth largest Standard Metropolitan Statistical Area (SMSA) in the country, the AQCR also contains the SMSA's of Trenton, New Jersey, and Wilmington, Delaware, with populations of one-third and one-half million, respectively. The major topographical feature of the area is the Delaware River which separates the Pennsylvania and Delaware portions of the AQCR from the State of New Jersey. The region lies near the path of low pressure systems which move across the country, resulting in changeable winds and weather in the region. The annual prevailing wind direction is from the west-southwest with the prevailing winds for the summer months being from the southwest and northerly winds prevailing during the winter. The proximity of the Delaware Bay helps to moderate temperatures, often encouraging the city heat island effect to change snow to rain, and also adds to the humidity in the summer months with the prevalence of maritime air. Precipitation occurs frequently but moderately, averaging about 41 inches per year. Philadelphia experiences some degree of inversion on approximately 200 days each year; however, on only about 5 days is there insubstantial heating and the inversion becomes relatively severe.

Philadelphia is quite highly industrialized, ranking third in the nation for overall manufacturing and first in the production of textiles, ships, and radios. Nevertheless, the inventoried emissions in the area indicate that space heating is currently the largest source category in the city, amounting to 44 percent of the total emissions, with industrial processes contributing 30 percent. The reader is directed to Volume VI of this report for a complete discussion of the subject city.

Concentrations of TSP in the ambient air have shown a fairly steady decrease since the early 1960's with the decrease leveling off in the past couple of years. The national annual secondary standard is generally being exceeded throughout the city with levels increasing closer to the center city area. Several sites have TSP annual mean concentrations exceeding levels of 100 $\mu g/m^3$ in 1974.

The locations of the 11 sites that were selected for filter analysis in Philadelphia are shown in Figure 10. Table 44 details the pertinent characteristics of these sites, and Table 45 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 46. The results for each of the 40 filters submitted for routine analysis from all sites except the NASN site are presented in Table 47. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 48. Seven filters underwent replicate analyses, and the results of this task are presented in Table 49.

Philadelphia was one of three study cities selected for particulate trends analysis. To accomplish this task, two or three filters for each of the calendar years 1965, 1970, 1971, 1973, and 1974 from NASN sampling sites were selected for microscopic analysis. The results of each filter analysis are presented in Table 50 and a composite summary for each year is presented in Table 51. Operation of the NASN site of historical interest was terminated at the end of 1973, so filters from two other NASN sites in Philadelphia were selected for 1974. In order to eliminate the complicating factor of site location, only the interval of 1965 and 1973 will be considered for the purpose of trend analysis.

It can be seen from Table 51 that there has been a consistent increase in the percent contribution of minerals since 1965. During the same time, the contribution of combustion products has been decreasing. The overall particulate loadings at that site have also shown marked decreases with the annual geometric mean going from 170 $\mu g/m^3$ in 1965 to 89 $\mu g/m^3$ in 1973. This indicates that even though the percent contribution of minerals is on the increase, the net concentration may be decreasing.

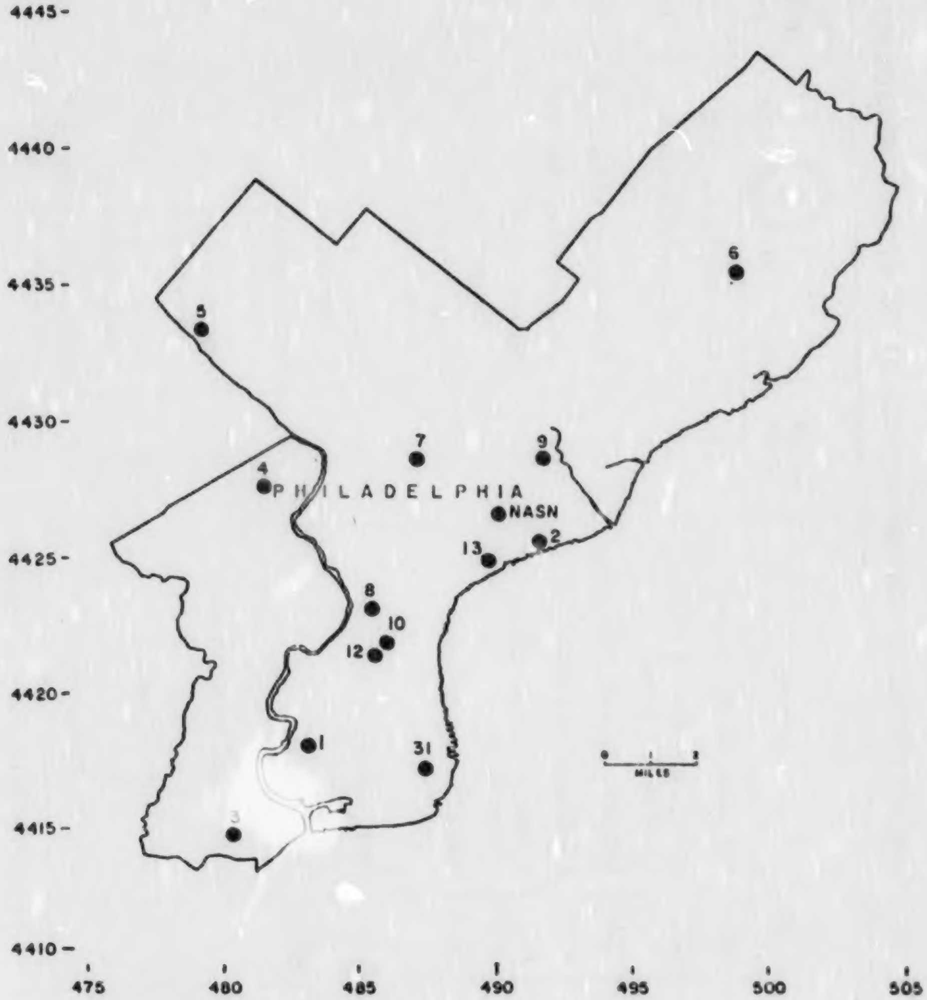
Of the eight non-NASN sites from which filters were analyzed for 1974, only one (Allegheny) showed higher amounts of combustion products than minerals. This site is in an industrial area and had the highest 1974 annual geometric mean of all sites in Philadelphia. All the other sites shown in Table 48 displayed a predominance of mineral material with the average values at each site ranging from 55 percent to 87 percent. Two sites were located so as to allow a comparison of sampler height with TSP levels and composition. The Camp station, 8A, is located in a parking lot adjacent to the Franklin Research Institute and the sampler is 13 feet off the ground. Another sampler is located on the roof of the Institute approximately 60 feet off the ground. The geometric mean for the 40 paired samples at the rooftop monitor and the Camp station monitor were 83 $\mu g/m^3$ and 110 $\mu g/m^3$, respectively. Filters from the two sites were examined microscopically for two sampling days and the results are shown in Table 47e. On November 1, 1974, the lower sampler had a much higher concentration presumably caused by local fugitive dust, probably generated by the parking lot. The higher percentage of minerals at the Camp station confirms that observation. On December 19, 1974, the composition at the two sites was very similar, however, and there is no evidence of monitor height influencing the results.

The composite particulate composition for all 1974 non-NASN filters from Philadelphia that underwent analyses, presented in Table 52, shows that the minerals quartz, calcite, and hematite account for nearly twice as much of the particulate mass as do combustion products. The average percent minerals is quite typical of the other 14 study cities (eighth highest) but the average percent combustion products is high (fourth highest).

Philadelphia was ranked among the lowest study cities in regard to average percent biological and rubber content.

Three of the filters from Philadelphia were also submitted for determination of particle size as a function of particle type, as shown in Figures 11 through 13. Two of these samples were subjected to chemical analyses. The sample from Broad and Lombard on December 19, 1974, had 9 $\mu g/m^3$ benzene solubles and about 18 $\mu g/m^3$ total carbon with most reported as organic carbon. The sample from Broad and Spruce on November 19, 1974, had 11 $\mu g/m^3$ benzene solubles and about 32 $\mu g/m^3$ total carbon, again nearly all reported as organic carbon.

This latter sample was also selected for detailed physical analysis, and the results are presented in Table 53. The Philadelphia Air Management Services Laboratory runs chemical analyses on daily samples collected at selected sites in the city. The results of some of these analyses are presented in Tables 54 through 61.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MILES

Figure 10. Location of monitoring sites in Philadelphia County

Table 44. CHARACTERISTICS OF MONITORING SITES IN THE CITY OF PHILADELPHIA

No.	AMS code	Address	Height, feet	Site characteristic	TSP 1974 geometric mean
1	DEF	Defense Supply Depot	13	Suburban-industrial	105
2	ALL	Allegheny Ave. & Delaware River	13	Suburban-industrial	122
4	BEL	Belmont Filter Station	13	Suburban-residential	72
6	N/E	Northeast Airport	13	Suburban-residential	64
8a	FRI	Franklin Research Institute	60	Center city-commercial	NA
8b	CAMP	Franklin Institute (CAMP)	11	Center City-commercial	119
10	SBR	South Broad & Spruce	13	Center city-commercial	NA
12	500	500 S. Broad	35	Center city-commercial	76
NASN 001		3200 Frankford Avenue	30	Center city-industrial	NA
NASN 002		2031 Race Street	11	Center city-commercial	NA
NASN 004		1501 E. Lycoming	17	Suburban-residential	NA

Note: NA - not applicable due to incomplete sampling.

Table 45. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (INTERNATIONAL AIRPORT, PHILADELPHIA)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
6/09/65						
10/07/65						
12/22/65						
3/24/70	t	t	12.1	11.4	240, 220, 230, 260 240, 280, 260, 250	250
8/26/70	0	0	6.9	6.3	200, 210, 220, 200 190, 230, 270, 200	210
9/22/70	0	0	8.2	7.9	200, 210, 220, 240 220, 220, 180, 210	210
1/19/71	0	0	9.5	9.1	260, 310, 260, 300 300, 280, 290, 270	280
12/03/71	0	0	6.5	5.4	330, 310, C, 290 220, 290, 290, 290	280
12/11/71	0	t	11.8	7.7	180, 210, 230, 280 320, 330, 290, 240	270
1/23/72	t	0.01	6.6	3.6	110, 100, 320, 220 290, 240, 230, 170	220
1/23/74	0	0	7.1	3.4	100, 90, C, 290 260, 240, 240, 340	270
9/08/74	0	0.79	5.5	2.9	350, 80, 350, 100 140, 130, 190, 140	120
9/26/74	0	0	7.1	5.8	260, 260, 280, 230 290, 320, 210, 240	270

Table 45 (continued). METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (INTERNATIONAL AIRPORT, PHILADELPHIA)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
11/01/74	0	0	6.8	6.4	230, 230, 240, 250 230, 280, 230, 250	250
11/19/74	0	0	6.8	5.8	230, 260, 270, 250 240, 230, 180, 170	230
12/07/74	0.07	0	8.1	3.4	360, 10, 70, 70 200, 190, 130, 150	120
12/19/74	t	0	6.9	5.6	240, 250, 170, 140 230, 230, 180, 220	210

Note: C = Calm
t = Trace

Table 46. ANNUAL AVERAGE CONCENTRATION OF SULFATE AND NITRATE IONS AT THE PHILADELPHIA, PENNSYLVANIA NASN SITE NO. 397140001 FOR 1972 AND 1973 AND SITE NO. 397140004 FOR 1974 (μg/m^3)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	16.14	14.16	3.36	3.08
1973	13.51	12.13	4.85	3.81
1974	15.24	13.33	4.14	3.66

Table 47a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PHILADELPHIA AND VICINITY (BROAD AND SPRUCE - NO. 10)

Date	8 September 1974			26 September 1974			19 November 1974			7 December 1974			19 December 1974		
TSP ($\mu g/m^3$)	123			161			189			112			169		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(9)			(7)			(9)			(5)	<1-150	15	(5)	1-50	9
Quartz	6	<1-100	5	4	<1-160	5	4+	<1-160	5	2+			3		
Calcite	1+	<1-100	5	1+	<1-100	5	3	<1-50	5	1			1		
Feldspars	1-			1-											
Hematite	1+	<1-60	0.5	1	<1-20	0.5	1	<1-50	0.5	2-			1		
Mica															
Combustion Products	(1)			(1-)			(1)			(5-)	<1-180	1	(2)	<1-80	2
Soot:															
Oil	1-	<1-175	0.5	1-			1								
Coal															
Soot													1		
Glassy fly ash													1		
Incinerator fly ash															
Burned wood															
Burned paper															
Magnetite															
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(0+)			(2+)			(0+)			(0+)			(3)	8-60	20
Iron or steel															
Rubber				2+	<1-800	100							3		

Table 47b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PHILADELPHIA AND VICINITY (BROAD AND LOMBARD - NO. 12)

Date	23 January 1974			8 September 1974			26 September 1974			19 November 1974			7 December 1974			19 December 1974		
TSP ($\mu g/m^3$)	141			56			100			115			91			54		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(5+)			(9)			(8+)			(9)			(4)	1-60	2	(1-)	<1-75	8
Quartz	2	1-50	15	5	<1-75	5	4	<1-50	5	4	<1-80	5	1					
Calcite	1	1-75	10	1+	<1-75	5	2+	<1-50	5	3	<1-50	5						
Feldspars	1-	1-30	10				1-			1-								
Hematite	2	1-10	1	2+	<1-20	0.5	1+	<1-20	0.5	1+	<1-30	0.5	2+					
Mica																		
Combustion Products	(4+)			(1)			(2-)			(1)			(6)	<1-45	2	(8+)	<1-80	<1
Soot:																		
Oil	4	<1-120	<0.5	1-	<1-200	0.5	1	<1-120	0.5	1-			6					
Coal	1-																	
Soot																8+		
Glassy fly ash							1-											
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(1)	6-15	12
Pollen																		
Spores																		
Paper																		
Starch																1		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)					
Iron or steel																		
Rubber																		

Table 47c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PHILADELPHIA AND VICINITY (DEFENSE — NO. 1, ALLEGHENY — NO. 2, AND BELMONT — NO. 4)

Site	Defense — No. 1			Allegheny — No. 2									Belmont — No. 4					
Date	26 September 1974			19 November 1974			7 December 1974			19 December 1974			23 January 1974			19 November 1974		
TSP ($\mu g/m^3$)	163			175			100			109			111			115		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9-)			(8)			(4)	<1-45	2	(1)	<1-2	1	(5+)	1-45	11	(7)		
Quartz	3+	<1-100	5	1+	<1-50	5	2-			1-			3+			1	<1-40	5
Calcite	3+	<1-100	3	2+	<1-75	5	1						2-			1+	<1-40	5
Feldspars				1-												1-		
Hematite	1+	<1-50	0.5	4	<1-30	<0.5	1+									4	<1-50	0.5
Mica																		
Combustion Products	(1+)			(1)			(6)	<1-70	<1	(9)	<1-90	<1	(4+)			(3)		
Soot:																		
Oil	1	<1-400	0.5	1-	<1-50	0.5										2	<1-100	0.5
Coal													1+					
Soot							6			9								
Glassy fly ash													3			1	1-25	6
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(1)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch				1	3-25	12												
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber																		

Table 47d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PHILADELPHIA AND VICINITY (N. E. AIRPORT — NO. 6)

Date	23 January 1974			8 September 1974			26 September 1974			19 November 1974			7 December 1974		
TSP ($\mu g/m^3$)	107			99			206			106			72		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(8+)			(9+)			(9)			(8)			(2+)	<1-75	3
Quartz	3	<1-50	10	6	<1-150	2	6	<1-50	5	4	<1-75	5	1		
Calcite	3	<1-50	5	2	<1-100	5	1+	<1-50	5	3	<1-50	5			
Feldspars	1-														
Hematite	2	<1-20	0.5	1	<1-50	0.5	1	<1-15	0.5	1	<1-30	0.5	1		
Mica															
Combustion Products	(2-)			(1-)			(1)			(2)			(8-)	<1-300	<1
Soot:															
Oil	1	<1-50	0.5	1-			1	<1-50	0.5	1	<1-150	0.5			
Coal															
Soot													8-		
Glassy fly ash	1-									1-	1-15	5			
Incinerator fly ash															
Burned wood															
Burned paper															
Magnetite															
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)		
Iron or steel															
Rubber															

Table 47e. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PHILADELPHIA AND VICINITY (CAMP — NO. 8A, FRI ROOF — NO. 8B)

Site	CAMP — No. 8A						FRI Roof — No. 8B					
Date	1 November 1974			19 December 1974			1 November 1974			19 December 1974		
TSP ($\mu g/m^3$)	264			NA[a]			199			133		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9+)			(4)	1-45	6	(7)			(4)	<1-66	4
Quartz	1+	<1-100	15	1			3	<1-80	5	3		
Calcite	7	<1-100	15	3-			2+	<1-80	5	1		
Feldspars												
Hematite	1	<1-50	0.5				1	<1-20	0.5	1-		
Mica												
Combustion Products	(1-)			(6)	1-20	1	(3)			(5+)	<1-50	2
Soot:												
Oil							1-	<1-100	0.5			
Coal												
Soot				5						4		
Glassy fly ash	1-			1-			2+	1-15	3	1+		
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(0+)			(0+)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(0+)			(0+)			(0+)			(1-)	5-58	25
Iron or steel												
Rubber										1-		

[a] Not Available

Table 48. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN PHILADELPHIA AND VICINITY

Site	Broad & Lombard – No. 12		Broad & Spruce – No. 10		N.E. Airport No. 6		Camp – No. 8A		FBI Roof No. 8B		Belmont No. 4		Allegheny No. 2		Defense – No. 1
No. of filters	6		5		5		2		2		2		3		1
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	—
Minerals	(60)	6-90	(69)	49-90	(74)	23-93	(67)	40-93	(55)	42-68	(62)	55-69	(44)	10-82	(87)
Quartz	27	2-48	39	29-58	40	10-60	13	10-15	30	29-30	22	10-34	12	6-16	35
Calcite	14	1-30	16	9-30	19	1-30	47	27-68	16	8-25	15	15-16	12	2-25	35
Feldspars	2	0-5	2	0-4	2	0-4	1	0-2	2	0-3	2	0-4	1	0-4	2
Hematite	17	0-25	12	8-16	12	10-20	6	3-8	7	5-10	23	5-40	19	2-38	15
Mica			<1		1	0-2			<1						<1
Combustion Products	(37)	8-84	(19)	6-47	(26)	7-77	(33)	7-60	(42)	32-53	(38)	31-45	(52)	8-89	(13)
Soot:															
Oil	20	0-60	4	0-10	7	0-10	1	0-2	2	0-5	9	0-18	2	0-6	10
Coal	2	0-4	1	0-2	1	0-2	1	0-1	1	0-2	9	3-15	<1	0-1	1
Soot	14	0-84	11	0-47	16	0-77	26	0-53	19	0-38			49	0-88	
Glassy fly ash	1	0-4	3	0-11	2	0-6	5	4-7	20	15-25	20	10-30	1	0-1	1
Incinerator fly ash	<1		<1		<1				<1		<1				1
Burned wood	<1								<1						
Burned paper	<1		<1		<1				<1		<1				
Magnetite															
Biological Material	(2)	0-10	(<1)		(<1)		(<1)		(<1)		(<1)		(3)	0-10	(<1)
Pollen	<1		<1		<1		<1		<1						<1
Spores	<1		<1		<1		<1		<1		<1		<1		<1
Paper	<1	0-1	<1		<1		<1		<1				<1		<1
Starch	2	0-10	<1		<1		<1		<1				3	<1-10	
Misc. plant tissue	<1		<1		<1		<1		<1		<1		<1		<1
Miscellaneous	(<1)	0-2	(12)	0-30	(<1)		(<1)		(3)	0-5	(<1)		(<1)	0-1	(<1)
Iron or steel	<1		<1		<1		(<1)		(<1)		<1		<1		<1
Rubber	<1	0-2	12	0-30	<1				3	<1-5			<1	0-1	

Table 49. RESULTS OF REPLICATE ANALYSES OF PHILADELPHIA FILTERS

Site	Broad & Lombard — No. 12						Allegheny — No. 2	
Date	23 January 1974		26 September 1974		19 December 1974		19 December 1974	
TSP (μg/m^3)	141		100		94		109	
Laboratory	A	A	A	B	A	B	A	B
Analysis	1	2	1	1	1	1	1	1
Components								
Minerals	(55)	(66)	(84)	(11)	(6)	(22)	(10)	(7)
Quartz	20	31	40		2		6	
Calcite	10	25	25		1		2	
Feldspars	5	4	4					
Hematite	20	6	15		3		2	
Mica		<1						
Combustion Products	(44)	(34)	(16)	(89)	(84)	(77)	(89)	(47)
Soot:								
Oil	40	25	10	13		28		
Coal	4	2	2					
Soot					84		88	
Glassy fly ash		2	4	76		49	<1	47
Incinerator fly ash		1						
Burned wood	<1							
Burned paper	<1	4						
Magnetite								
Biological Material	(1)	(<1)	(<1)		(10)	(1)	(<1)	(46)
Pollen		<1	<1					
Spores	<1	<1	<1					
Paper	1	<1	<1				<1	
Starch	<1	<1	<1		10		<1	
Misc. plant tissue	<1	<1	<1					
Miscellaneous	(<1)	(<1)	(<1)					
Iron or steel	<1	<1	<1					
Rubber								

Table 50a. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 397140001 IN PHILADELPHIA (1965 AND 1970)

Date	9 June 1965			7 October 1965			22 December 1965			24 March 1970			26 August 1970			22 September 1970		
TSP ($\mu g/m^3$)	170			215			279			136			166			287		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(6+)			(4+)			(6)			(6+)			(7)			(6+)		
Quartz	3	<1-60	3	2	<1-40	5	3	<1-125	5	3+	<1-240	5	3	<1-50	5	3	<1-80	5
Calcite	2	<1-40	3	1	<1-40	5	1+	<1-125	5	1+	<1-50	5	2	<1-50	5	1+	<1-60	5
Feldspars	1-									1-			1-			1-		
Hematite	1	<1-40	0.5	1	<1-60	0.5	1	<1-80	0.5	1	<1-30	0.5	1+	<1-40	0.5	1+	<1-80	0.5
Mica																		
Combustion Products	(3-)			(6-)			(3+)			(3-)			(1+)			(2)		
Soot:																		
Oil	2	<1-140	0.5	4+	<1-120	0.5	3	<1-200	0.5	2	<1-120	0.5	1	<1-150	0.5	1+	<1-120	0.5
Coal																		
Glassy fly ash	1-			1						1-			1-	<1-30	10	1-		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1)			(0+)			(1-)			(1)			(1+)			(1+)		
Iron or steel																		
Rubber	1	<1-14	30				1-	<1-125	30	1	<1-100	30	1+	<1-150	30	1+	<1-150	30

Table 50b. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 397140001 IN PHILADELPHIA (1971 AND 1973)

Date	19 January 1971			3 December 1971			11 December 1971			22 April 1973			12 November 1973		
TSP (µg/m^3)	95			136			200			338			120		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(7+)			(7-)			(7)			(7)			(7+)		
Quartz	3	<1-50	8	2+	<1-50	3	3	<1-80	5	3	<1-100	3	3	<1-80	3
Calcite	3	<1-50	8	2	<1-75	3	2+	<1-80	5	3	<1-80	3	3	<1-80	3
Feldspars							1-			1-					
Hematite	1	<1-20	0.5	2	<1-8	0.5	1	<1-80	0.5	1	<1-40	0.5	1	<1-50	0.5
Mica															
Combustion Products	(1+)			(2+)			(3-)			(1)			(2)		
Soot:															
Oil	1	<1-10	0.5	2+	<1-150	0.5	2	<1-150	0.5	(1)	<1-75	0.5	1		
Coal															
Glassy fly ash							1-						1	<1-40	10
Incinerator fly ash															
Burned wood															
Burned paper															
Magnetite															
Biological Material	(0+)			(0+)			(0+)			(1)			(0+)		
Pollen										1	<10-50	16			
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(1)			(1)			(1-)			(1)			(1-)		
Iron or steel															
Rubber	1	<1-80	40	1	<1-100	30	1-	<1-100	40	1	<1-150	30	1-	<1-100	40

Table 50c. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NOS. 391740002 AND 397140004 IN PHILADELPHIA (1974)

Site	397140002			397140004					
Date	23 January 1974			8 September 1974			19 November 1974		
TSP ($\mu g/m^3$)	NA[a]			48			151		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(7+)			(5+)			(3)	<1-45	3
Quartz	3	<1-80	5	2+	<1-80	2	1		
Calcite	3	<1-100	5	1+	<1-50	2	1		
Feldspars									
Hematite	1	<1-20	0.5	1	<1-	0.5	1		
Mica									
Combustion Products	(2-)			(2)			(6+)	<1-30	7
Soot:									
Oil	1	<1-100	0.5	2	<1-50	0.5	2+		
Coal									
Fine soot							4		
Glassy fly ash	1-	<1-15	2						
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Material	(0+)			(0+)			(0+)		
Pollen									
Spores									
Paper									
Starch									
Misc. plant tissue									
Miscellaneous	(1)			(2+)			1-	5-270	30
Iron or steel									
Rubber	1	<1-125	30	2+	<1-100		1-		

[a] Not Available

Table 51. COMPOSITE SUMMARY OF FILTER ANALYSES FOR NASN SITES IN PHILADELPHIA AND VICINITY (BY YEARS)

Site No.	397140001		397140001		397140001		397140001		397140002	397140004	
Year	1965		1970		1971		1973		1974	1974	
No. of filters	3		3		3		2		1	2	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	Quantity percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	–	Average	Range
Minerals	(56)	43-64	(66)	64-69	(70)	67-75	(72)	70-75	(73)	(41)	28-53
Quartz	27	20-30	32	30-35	28	25-30	30	30	30	19	12-25
Calcite	15	10-20	17	15-20	25	20-30	29	28-30	30	11	8-15
Feldspars	3	2-4	4	4	3	2-4	3	3-4	3	2	0-3
Hematite	11	10-12	13	10-15	14	10-20	10	8-12	10	9	8-10
Mica											
Combustion Products	(39)	26-57	(21)	16-26	(21)	13-26	(16)	12-20	(17)	(43)	22-65
Soot:											
Oil	32	20-45	15	10-20	18	10-25	9	8-10	10	22	20-25
Coal	2	2	1	0-2	1	0-2	2	1-2	2	<1	
Fine soot										19	0-38
Glassy fly ash	5	3-10	5	4-6	2	0-4	5	3-8	5	2	2
Incinerator fly ash					<1	0-1					
Burned wood											
Burned paper											
Magnetite											
Biological Materials	(<1)		(<1)		(<1)		(5)	<1-10	(<1)	(<1)	
Pollen	<1		<1				4	<1-8		<1	
Spores	<1		<1		<1		<1		<1	<1	
Paper	<1		<1		<1		<1			<1	
Starch	<1		<1		<1		<1		<1	<1	
Misc. plant tissue	<1		<1		<1		1	<1-2	<1	<1	
Miscellaneous	5	<1-10	(13)	10-15	(9)	5-12	(7)	5-8	(10)	(16)	6-25
Iron or steel	<1		<1		<1		<1		<1	<1	
Rubber	5	<1-10	13	10-15	9	5-12	7	5-8	10	16	6-25

Table 52. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN PHILADELPHIA

No. of filters	26[a]	
	Quantity, percent	
Components	Average	Range
Minerals	(64)	6-93
Quartz	29	2-60
Calcite	19	1-68
Feldspars	2	0-5
Hematite	15	0-40
Mica	<1	
Other		
Combustion Products	(33)	6-89
Soot:		
Oil	8	0-60
Coal	2	0-15
Misc. soot	18	0-88
Glassy fly ash	5	0-30
Incinerator fly ash	<1	
Burned wood	<1	
Burned paper	<1	
Magnetite		
Carbon black		
Other		
Biological Material	(1)	0-10
Pollen	<1	
Spores	<1	
Paper	<1	
Starch	1	0-10
Misc. plant tissue	<1	
Leaf trichomer		
Miscellaneous	(2)	0-30
Iron or steel	<1	
Rubber	2	0-30
Other		

[a] Excludes Filter analyses of NASN site samples.

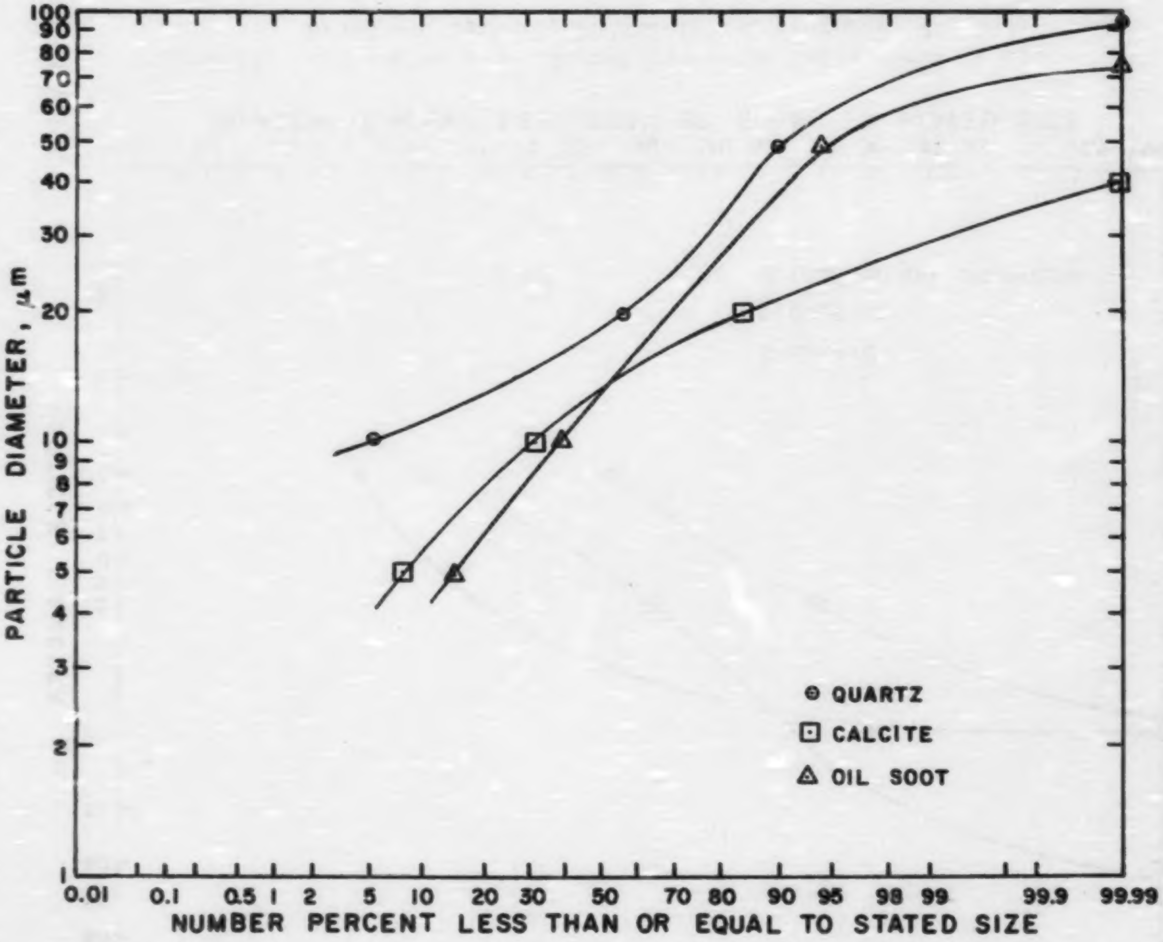

Figure 11. Cumulative size distribution for three particle types, Broad and Spruce, Philadelphia, November 19, 1974

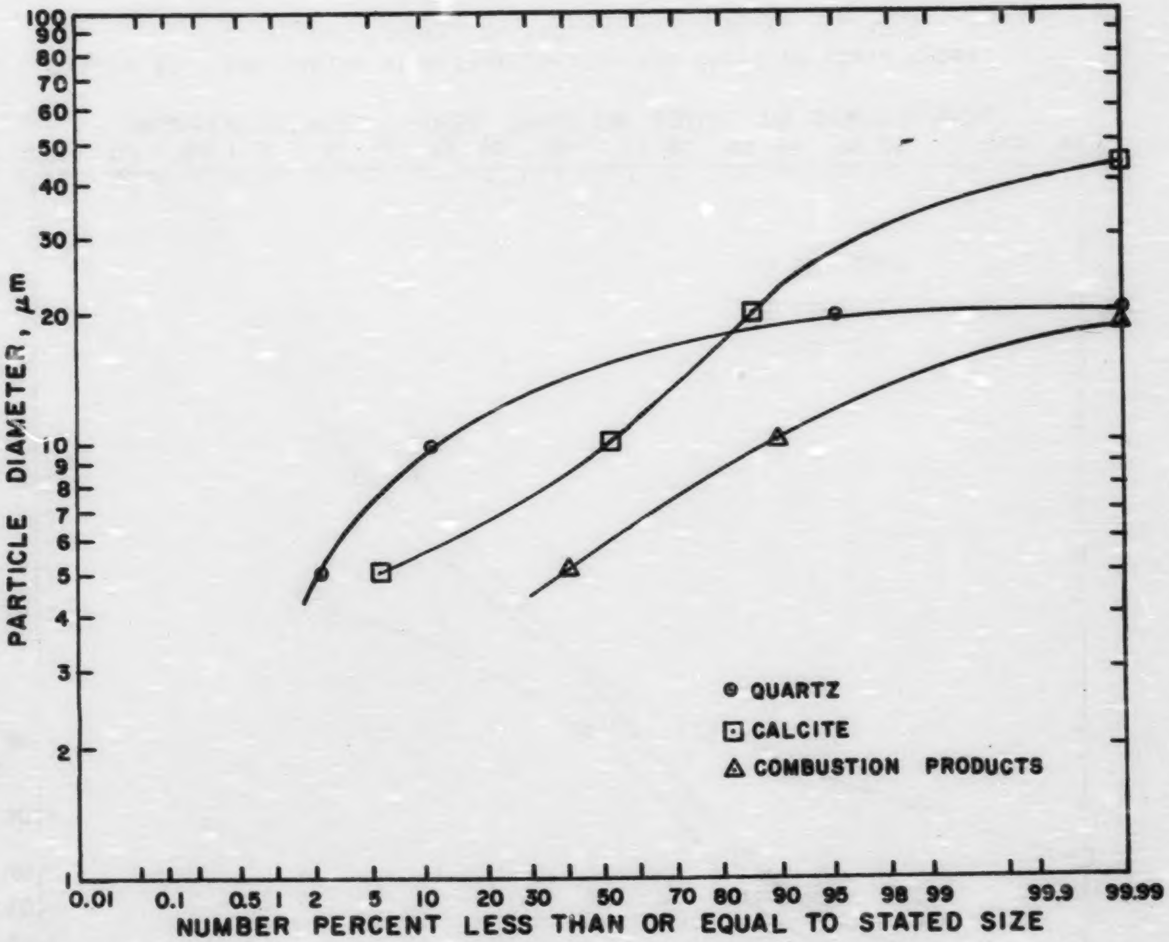

Figure 12. Cumulative size distributions for three particle types, Broad and Lombard, Philadelphia, September 26, 1974

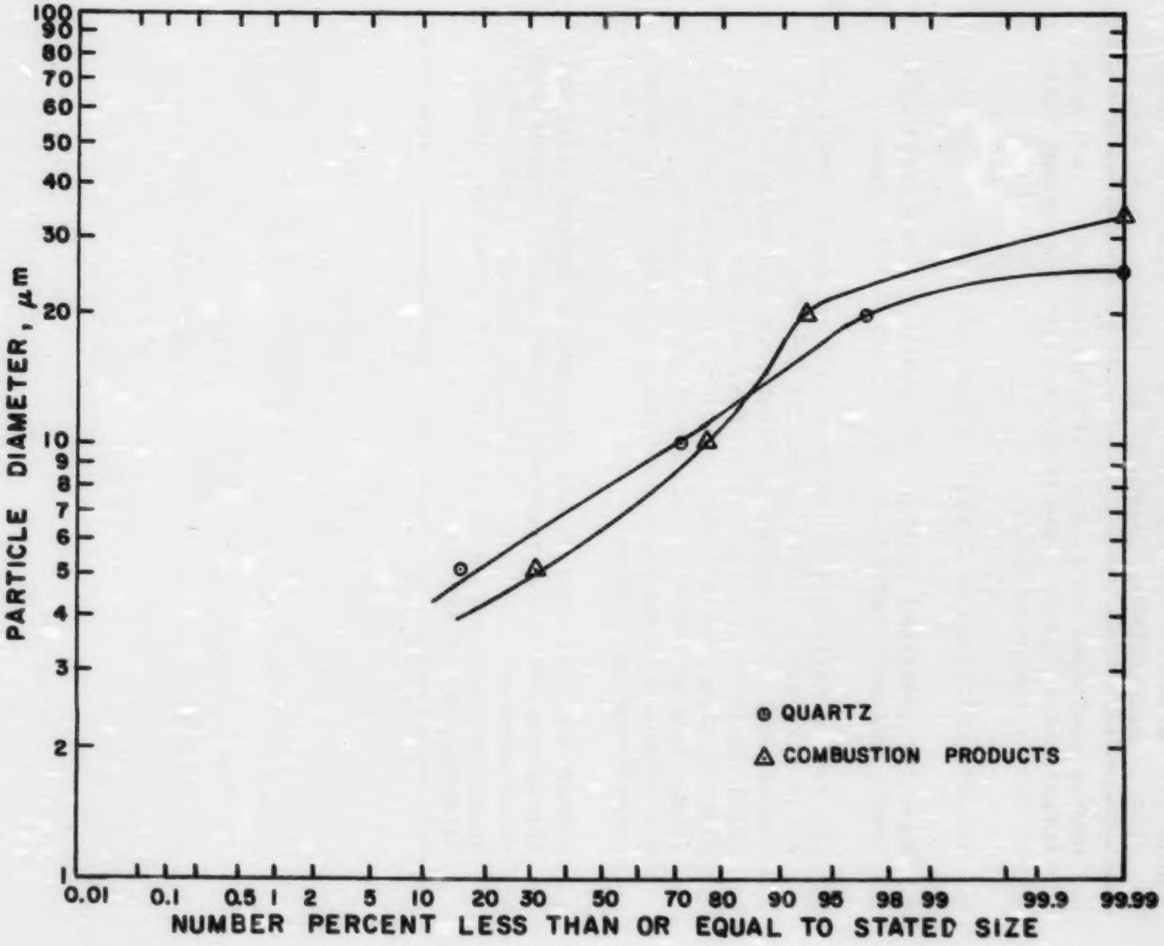

Figure 13. Cumulative size distributions for two particle types, Broad and Lombard, Philadelphia, December 19, 1974

Table 53. DETAILED PHYSICAL EXAMINATION: BROAD AND SPRUCE, PHILADELPHIA, NOVEMBER 19, 1974

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a. Quartz confirmed by dispersion staining and (-) uniaxial interference figure. EDXRA shows only silicon and trace of iron (from hematite).

b. Calcite confirmed by EDXRA - shows only calcium.

c. Hematite confirmed by high refractive indices, birefringence, and deep red color. EDXRA shows only iron.

d. Oil soot confirmed (as far as possible, due to small particle size and variability of fly ash due to operating conditions) by brittleness, morphology and especially EDXRA analysis showing: aluminum, silicon (both from clay feldspar impurities), calcium, sulfur, chlorine (these two as normal constituents of oil soots), iron and vanadium (a normal constituent of oils). The major constituent was carbon.

e. Rubber was confirmed by its elastomeric nature, surface appearance and EDXRA spectrum showing mostly carbon with minor amounts of calcium, aluminum, silicon (all probably from road wear products), sulfur, chlorine, iron, titanium, and zinc.

Table 54. MONTHLY MEAN ALUMINUM LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, μg/m^3

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
500 S. Broad	1.30	1.52	1.13	1.66	1.86	2.18	1.86	0.97	0.72	0.96	1.61	1.82	1.47
1501 E. Lycoming	1.36	1.26	1.48	1.32	1.99	1.96	1.68	1.05	0.95	0.90	1.89	2.17	1.50
S. E. Sewage	1.18	1.35	1.57	1.31	1.63	2.14	1.50	0.90	0.70	0.95	1.92	2.11	1.44

Table 55. MONTHLY MEAN CADMIUM LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, μg/m^3

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
500 S. Broad	.0044	.0031	.0039	.0029	.0032	.0036	.0048	.0018	.0051	.0044	.0070	.0042	.0041
1501 E. Lycoming	.0064	.0056	.0063	.0042	.0033	.0045	.0040	.0029	.0023	.0056	.0070	.0060	.0048

Table 56. MONTHLY MEAN COPPER LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, μg/m^3

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
500 S. Broad	0.161	0.079	0.076	0.079	0.098	0.239	0.211	0.485	0.361	0.208	0.140	0.163	0.192
1501 E. Lycoming	0.204	0.109	0.124	0.254	0.190	0.193	0.207	0.336	0.224	0.307	0.241	0.238	0.219

Table 57. MONTHLY MEAN IRON LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, $\mu g/m^3$

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
500 S. Broad	1.71	1.36	1.31	1.32	1.38	1.66	1.51	2.25	1.32	1.32	1.07	1.35	1.46
1501 E. Lycoming	2.18	1.50	1.59	1.62	1.79	1.77	1.55	1.68	1.48	1.43	1.37	1.57	1.63
S. E. Sewage	1.37	1.51	1.80	3.79	1.76	1.65	1.89	2.25	1.73	1.96	1.36	2.09	1.93

Table 58. MONTHLY MEAN LEAD LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, $\mu g/m^3$

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
1501 E. Lycoming	2.00	0.85	0.75	0.83	0.72	0.60	0.73	0.70	0.83	1.03	0.83	1.19	0.92
S. E. Sewage	1.11	1.13	1.11	1.31	1.24	1.13	1.06	1.26	1.38	1.57	1.44	1.38	1.26

Table 59. MONTHLY MEAN MAGNESIUM LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, $\mu g/m^3$

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
500 S. Broad	0.64	0.53	0.57	0.59	0.57	0.58	0.55	0.53	0.45	0.44	0.41	0.48	0.53
S. E. Sewage	0.64	0.66	0.62	0.57	0.61	0.47	0.47	0.49	0.40	0.39	0.44	0.52	0.52

Table 60. MONTHLY MEAN NICKEL LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, $\mu g/m^3$

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
500 S. Broad	0.065	0.059	0.037	0.035	0.031	0.023	0.017	0.021	0.032	0.031	0.034	0.039	0.035
1501 E. Lycoming	0.061	0.039	0.042	0.043	0.034	0.025	0.014	0.037	0.027	0.030	0.038	0.039	0.036

Table 61. MONTHLY MEAN SULFATE LEVELS AT SELECTED PHILADELPHIA SITES FOR 1974, $\mu g/m^3$

Site	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
1501 E. Lycoming	39.6	21.6	18.3	21.5	19.0	17.4	16.4	19.5	21.5	24.0	22.4	21.4	21.9

WASHINGTON

The National Capital Interstate Air Quality Control Region (NCIAQCR) is situated on the flat Atlantic Coastal Plain and the gently rolling Piedmont Plateau. The terrain to the east is generally flat with elevations of less than 100 feet above mean sea level. Gentle rolling hills with elevations of 200 to 500 feet extend to the Blue Ridge Mountains at the western edge of the region. These mountains warm and dry the westerly winds reaching the region. The AQCR is located 35 miles west of Chesapeake Bay, far enough inland from the ocean to escape the sea breeze effect. In general, the topography of the area permits free air movement with few channeling effects. Measurable precipitation is evenly distributed throughout the year, occurring about 1 day in 3 except 1 day in 4 during autumn. The annual rainfall averages about 39 inches per year. The reader is directed to Volume VII of this report for a complete discussion of the subject city.

There were nine hi-vol monitoring sites operating during 1974. The annual mean TSP concentrations at two center-city sites exceeded the national primary standards, while the other seven sites had levels between 50 and 70 $\mu g/m^3$. The trend in TSP levels has been generally downward for the last several years, although the 1974 data generally showed an increase of a few $\mu g/m^3$ over 1973 levels.

The locations of the seven sites that were selected for filter analysis in Washington are shown in Figure 14. Table 62 details the pertinent characteristics of these sites, and Table 63 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 64. The results for each of the 33 filters submitted for routine analysis are presented in Table 65. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 66. Five filters underwent replicate analyses, and the results are presented in Table 67.

The composite particulate characterization for all filters from Washington that underwent routine analysis, presented in Table 68, shows that minerals predominate, comprising nearly three quarters of the TSP. Of the 14 study cities Washington was ranked sixth highest in average percent minerals. Quartz was the major constituent with somewhat lesser quantities of hematite and calcite. Although there were some site-to-site variations in the apparent composition of the TSP, there were no identifiable factors for the causes of the variations.

Washington was ranked second highest of the study cities in average percent biologicals even though the citywide average for the 23 filters analyzed was only 5 percent. It is apparent that biological materials, especially pollen, can sometimes have a significant impact on the TSP levels. On April 22, 1974, with moderate winds from the south-southwest, Washington apparently experienced very high levels of suspended pollen.

The four filters selected for analysis for that day ranged from 8 percent to 45 percent pollen, with most of the pollen identified as pine pollen. If the percent pollen identified on the filters can be multiplied by the TSP loadings for the filters for that day, then the 24-hour average concentration of pollen ranged from 13 $\mu g/m^3$ at the General Hospital to 154 $\mu g/m^3$ at the American Chemical Society site.

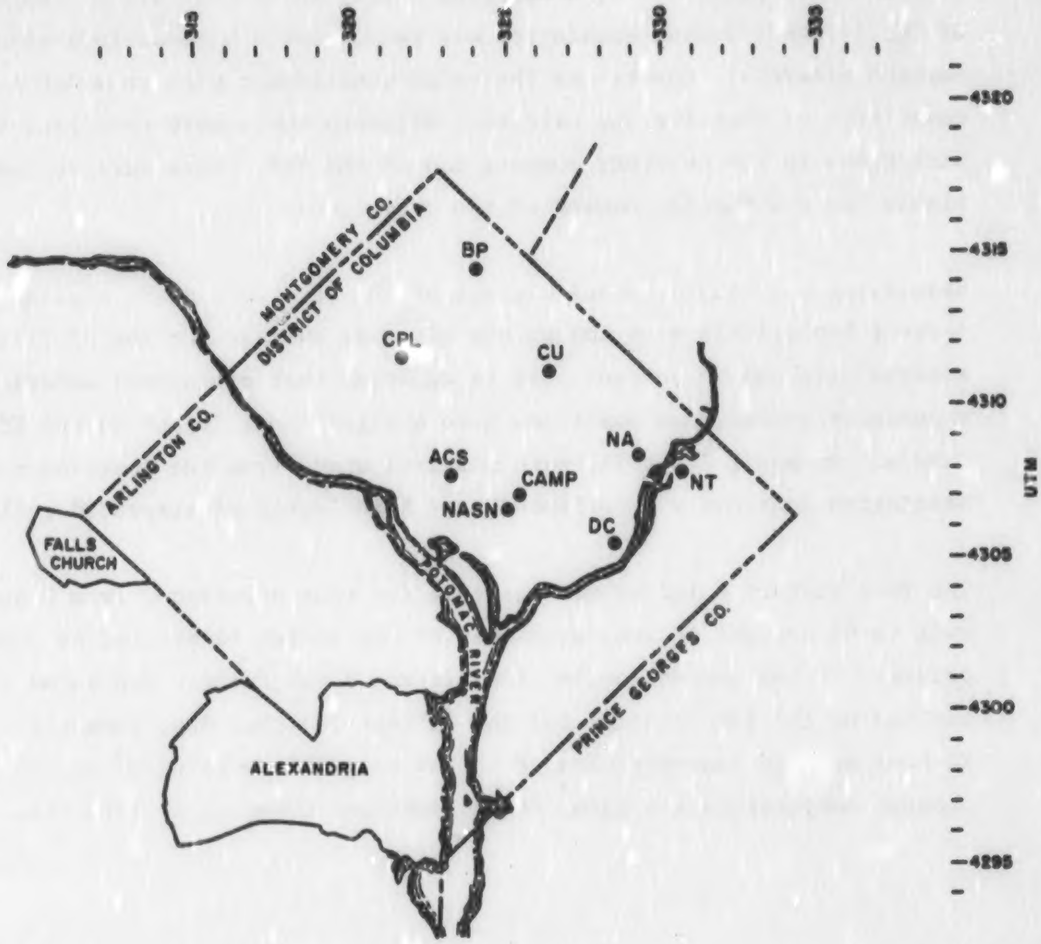
315
320
325
330
335
4320
4315
4310
4305
4300
4295
UTM
MONTGOMERY CO.
DISTRICT OF COLUMBIA
ARLINGTON CO.
FALLS CHURCH
ALEXANDRIA
PRINCE GEORGES CO.
POTOMAC RIVER
BP
CPL
CU
NA
NT
ACS
CAMP
NASN
DC

Figure 14. District of Columbia hi-vol monitoring network

Table 62. LAND-USE AND PARTICULATE SOURCES SURROUNDING THE MONITORING SITES

GCA code	Address	1974 TSP geometric mean, $\mu g/m^3$	Land use	Height above ground, feet
CAMP	CAMP Station 427 N.J. Ave. NW	102	Construction in surrounding area	15
NASN	Municipal Center 301 Indiana Ave. NW	92[a]	In downtown office area; construction SE	80
CU	Catholic University 620 Michigan Ave. NE	70	Adjacent to residential and commercial areas; hospitals N, SW, W; influence of subway construction E, N	35
ACS	American Chemical Society M and 16th St., NW	67	In the midst of office buildings and hotels	100
NA	National Arboretum 24th & R St. NE	59	Some construction near monitor during November	3
CPL	Cleveland Park Library Conn. & Macom NW	54	Adjacent to residential area (W); on heavily-travelled route (E)	20
NT	Nevel Thomas School Anacostia & Grant NE	54	Power plant and incinerator 1/2 mile W; highway 150, E	60
DC	D.C. General Hospital 19th & Mass. Ave. SE	52	Power plant NE 1/4 mile; stadium nearby; construction SW and SE; subway construction NW	40

[a] NASN site, sampling one in every 12 days.

Table 63. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (WASHINGTON, D.C.)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hours obs.	Resultant
2/15/74	0	t	10.6	10.1	70, 40, 30, 40 30, 50, 50, 90	50
2/21/74	0	0.01	5.3	4.5	210, 240, C, C 200, 190, 130, 170	180
2/24/74	0	t	9.4	9.0	50, 50, 80, 80 80, 100, 100, 80	80
4/01/74	t	0.01	6.0	1.1	260, 320, 330, 180 30, 130, 150, 60	90
4/22/74	0.03	0	14.2	14.2	200, 200, 210, 210 210, 210, 210, 210	210
8/14/74	0.12	t	6.3	2.0	210, 210, 30, 330 230, 330, 100, 260	290
8/23/74	t	0.27	6.5	5.8	240, 270, C, 240 200, 180, 190, 210	210
10/25/74	t	0	7.5	5.1	200, 200, 200, 190 180, 200, 330, 330	210

Note: C = Calm
t = Trace

Table 64. ANNUAL AVERAGE CONCENTRATION OF SULFATE AND NITRATE IONS AT THE WASHINGTON, D.C. NASN SITE NO. 090020001 (μg/m^3)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	13.83[a]	12.86[a]	2.88[a]	2.52[a]
1973	10.66[a]	9.66[a]	3.11[a]	2.79[a]
1974	12.95[a]	12.13[a]	3.25[a]	2.77[a]

[a] Indicates insufficient data for statistically valid year.

Table 65a. RESULTS OF FILTER ANALYSES — SELECTED SITES IN WASHINGTON, D. C. (AMERICAN CHEMICAL SOCIETY — ACS)

Date	21 February 1974			1 April 1974			22 April 1974			23 August 1974			25 October 1974		
TSP (μm/m^3)	113			89			342			56			85		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7+)			(6+)			(4)			(6+)			(8)		
Quartz	4+	<1-60	5	3	<1-70	5	1+	<1-50	3	2	1-100	5	4	<1-40	3
Calcite	1	<1-60	5	1	<1-40	5	1	<1-50	5	1	<1-20	5	2	<1-30	5
Feldspars	1-						1-			1-			1-		
Hematite	1+	<1-20	0.5	2	<1-40	0.5	1	<1-40	0.5	3	<1-30	0.5	1+	<1-60	0.5
Mica															
Combustion Products	(2+)			(4+)			(1+)			(1)			(2)		
Soot:															
Oil	1	<1-100	0.5	2	<1-150	0.5	1	<1-150	0.5	1-	<1-150	0.5	2	<1-150	0.5
Coal															
Glassy fly ash	1	<1-12	6	1+	<1-30	6									
Incinerator fly ash															
Burned wood															
Burned paper															
Magnetite															
Biological Materials	(0+)			(0+)			(5-)			(1-)			(0+)		
Pollen							4+	20-60	40						
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(0+)			(0+)			(0+)			(2)			(0+)		
Iron or steel															
Rubber										1	<1-250	25			
Glass										1	1-100	75			

Table 65b. RESULTS OF FILTER ANALYSES — SELECTED SITES IN WASHINGTON, D. C. (NEVEL THOMAS SCHOOL — NTS)

Date	15 February 1974			21 February 1974			26 February 1974			22 April 1974			23 August 1974			25 October 1974		
TSP ($\mu g/m^3$)	72			66			99			186			61			115		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8+)			(8+)			(7)			(8)			(8-)			(7)		
Quartz	2	<1-150	1	3	<1-50	3	3+	<1-30	2	4	<1-60	5	4	<1-40	3	1+	<1-60	3
Calcite	4+	<1-100	1	4	<1-60	3	2	<1-30	2	1	<1-50	5	1+	<1-30	5	1-	<1-50	5
Feldspars													1-			1-		
Hematite	1+	<1-20	0.5	1+	<1-30	0.5	1+	<1-30	0.5	2+	<1-30	0.5	2-	<1-20	0.5	4	<1-30	0.5
Mica																		
Clays																1-	<0.5	<0.5
Combustion Products	(2-)			(1+)			(3)			(1+)			(2+)			(3)		
Soot:																		
Oil	1	<1-80	0.5	1	<1-150	0.5	2	<1-300	0.5	1-			1+	<1-100	0.5	2+	<1-100	0.5
Coal	1-						1-			1-			1-			1-		
Glassy fly ash							1-			1-			1-					
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(1)			(0+)			(0+)		
Pollen										1	10-60	50						
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber																		

Table 65c. RESULTS OF FILTER ANALYSES — SELECTED SITES IN WASHINGTON, D. C. (CATHOLIC UNIVERSITY — CU)

Date	21 February 1974			1 April 1974			22 April 1974			16 August 1974			23 August 1974			25 October 1974		
TSP ($\mu g/m^3$)	101			64			138			123			48			103		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(6+)			(5)			(6+)			(6-)			(7+)			(7)		
Quartz	2+	<1-80	3	1+	<1-60	3	3	<1-80	2	3	<1-250	6	4	<1-70	5	2	<1-80	3
Calcite	2	<1-70	3	1+	<1-60	3	1+	<1-6	4	1-	<1-30	5	1+	<1-60	5	1	<1-50	5
Feldspars				1-									1-					
Hematite	1+	<1-20	0.5	1+	<1-60	0.5	1+	<1-40	0.5	2	<1-	0.5	1+	<1-50	0.5	4	<1-50	0.5
Mica																		
Combustion Products	(4-)			(5)			(1+)			(3)			(2+)			(2)		
Soot:																		
Oil	[illegible]	<1-200	0.5	2	<1-150	0.5	1	<1-150	0.5	1-	<1-200	0.5	1	<1-150	0.5	1+	<1-200	0.5
Coal				1-						1-	<1-50	20						
Glassy fly ash	1-	<1-20	6	2+	<1-30	6	1-			2	<1-30	6	1	<1-50	5	1-	<1-12	6
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(2)			(0+)			(0+)			(0+)		
Pollen							2	20-60	50									
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(1)			(0+)			(1-)		
Iron or steel																		
Rubber																		
Iron rust										1	<1-250	50				1-	<1-200	75

Table 65d. RESULTS OF FILTER ANALYSES — SELECTED SITES IN WASHINGTON, D. C.

Site	D. C. General Hospital — DCG						CAMP — CA						Cleveland Park — CO			National Arboretum — NA		
Date	1 April 1974			22 April 1974			14 August 1974			23 August 1974			14 August 1974			25 October 1974		
TSP ($\mu g/m^3$)	60			44			47			110			125			47		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7)			(5+)			(7)			(8+)			(8+)			(8)		
Quartz	4	<1-50	5	4	<1-80	5	3+	<1-80	2	3+	<1-100	3	6	<1-20	5	1+	<1-60	3
Calcite	1	<1-40	5	1	<1-40	5	1+	<1-70	5	1	<1-80	5	1-	<1-20	5	1	<1-60	5
Feldspars	1-			1-			1-			1-						1-		
Hematite	2-	<1-40	0.5	1	<1-40	0.5	1+	<1-30	0.5	3+	<1-30	0.5	1+	<1-50	0.5	5	<1-50	0.5
Mica																		
Combustion Products	(3-)			(1-)			(3)			(2-)			(1+)			(2)		
Soot:																		
Oil	1	<1-150	0.5				2+	<1-150	0.5	1-	<1-200	0.5	1-	<1-100	0.5	1	<1-200	0.5
Coal										1-						1-		
Glassy fly ash	1	1-20	6				1-			1-	<1-20	6	1	<1-15	5	1-		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(3)			(0+)			(0+)			(0+)			(0+)		
Pollen				3	20-60	50												
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber																		

Table 65e. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN WASHINGTON, D.C.

Site	NASN — No. 090020001			NASN — No. 090020003		
Date	25 December 1974			25 December 1974		
TSP (μg/m^3)	NA			NA		
Components	Quan-tity, tenths	Size range, μm	Avg. size, μm	Quan-tity, tenths	Size range, μm	Avg. size, μm
Minerals	(5)			(6)		
Quartz	3	<1-150	2	4	<1-200	2
Calcite	1	<1-100	2	1	<1-100	2
Feldspars	0+			0+		
Hematite	1	<1-100	0.5	1-	<1-20	0.5
Mica						
Combustion Products	(3)			(2-)	<1-100	0.5
Soot:						
Oil	1-			1		
Coal	1-	<1-100	30	1-		
Glassy fly ash	2	<1-100	20	0+		
Incinerator fly ash						
Burned wood						
Burned paper				<1		
Magnetite						
Biological Material	(<1)			(<1)		
Pollen	<1					
Spores	<1			<1		
Paper	<1			<1		
Starch	<1			<1		
Misc. plant tissue	<1			<1		
Miscellaneous	(2)			(2+)		
Iron or steel	<1			<1		
Rubber	2	<1-200	30	2+	<1-150	30

Table 66. COMPOSITE SUMMARY OF FILTER ANALYSES – SELECTED SITES IN WASHINGTON, D.C.

Site	Nevel Thomas School – NTS		Catholic University – CU		American Chem. Soc. – ACS		D. C. General Hospital – DCC		CAMP – CA		Cleveland Park – CO	National Arboretum – NA	NASN No. 090020001	NASN No. 020090003
No. of filters	6		6		5		2		2		1	1	1	1
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	Quantity, percent	Quantity, percent	Quantity, percent
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	–	–	–	–
Minerals	(78)	69-87	(63)	49-74	(65)	39-79	(68)	65-72	(76)	69-84	(85)	(79)	(51)	(58)
Quartz	30	15-40	27	15-40	30	15-45	40	40	35	35	60	15	30	40
Calcite	23	5-45	13	5-20	13	10-20	10	10	12	10-15	7	10	8	10
Feldspars	3	2-4	3	2-4	4	3-4	4	4	4	4	2	4	3	3
Hematite	21	15-40	20	15-40	18	10-30	13	10-17	25	15-35	15	50	10	5
Mica	<1	0-<1	<1	0-<1	<1	0-1	1	0-1			1			
Clay	1	0-5												
Combustion Products	(21)	13-31	(30)	16-49	(21)	10-37	(16)	5-26	(24)	16-31	(15)	(18)	(29)	(17)
Soot:														
Oil	14	4-25	15	5-30	13	5-20	6	2-10	16	6-25	5	10	4	10
Coal	4	1-4	3	2-5	2	1-3	2	1-3	3	2-4	<1	4	5	4
Glassy fly ash	3	2-4	12	4-20	6	<1-15	6	2-10	5	4-6	10	4	20	3
Incinerator fly ash	<1	<1-2	<1		<1	<1-2	1	0-2	<1		<1	<1		
Burned wood	<1		<1		<1		<1				<1			
Burned paper	<1		<1		<1		1	0-1	<1		<1	<1		<1
Magnetite														
Biological Material	(1)	(<1-8)	(4)	<1-21	(10)	<1-47	(16)	2-30	(<1)		(<1)	(3)	(<1)	(<1)
Pollen	1	0-8	3	<1-20	9	<1-45	15	<1-30	<1		<1	<1	<1	
Spores	<1		<1		<1		<1		<1		<1	<1	<1	<1
Paper	<1		<1		<1		<1		<1			<1	<1	<1
Starch			<1		<1		<1		<1				<1	<1
Misc. plant tissue	<1		1	<1-1	1	<1-3	1	0-2	<1		<1	3	<1	<1
Miscellaneous	(<1)		(3)	<1-10	(4)	<1-20	(<1)		(<1)		(<1)	(<1)	(20)	(25)
Iron or steel	<1		<1		<1		<1		<1		<1		<1	<1
Rubber	<1		<1	0-1	2	0-10	<1		<1			<1	20	25
Iron rust			3	0-10										
Glass					2	0-10								

Table 67. RESULTS OF REPLICATE ANALYSES OF WASHINGTON, D. C. FILTERS

Site	American Chemical Society – ACS					Catholic University – CU				D. C. General Hospital – DCG	
Date	21 Feb. 1974		22 April 1974			1 April 1974		23 Aug. 1974		22 April 1974	
TSP ($\mu g/m^3$)	113		342			64		48		44	
Laboratory	A	A	A	A	B	A	B	A	B	A	A
Analysis	1	2	1	2	1	1	1	1	1	1	2
Components											
Minerals	(74)	(30)	(39)	(62)	(27)	(49)	(15)	(74)	(48)	(65)	(62)
Quartz	45	20	15	30		15		40		40	30
Calcite	10	6	10	20		15		15		10	20
Feldspars	4		4	2		4		4		4	2
Hematite	15	4	10	10		15		15		10	10
Mica	<1							<1		1	
Combustion Products	(25)	(69)	(14)	(8)	(37)	(49)	(86)	(26)	(52)	(5)	(8)
Soot:											
Oil	10	7	10	5	7	20	8	12	8	2	5
Coal	3	20	2	1		4		2		1	1
Glassy fly ash	10	40	2	2	30	25	76	10	44	2	2
Incinerator fly ash	2		<1			<1		<1			
Burned wood	<1										
Burned paper	<1					<1					
Magnetite											
Coked coal		2									
Biological Material	(<1)	(<1)	(47)	(25)	(36)	[illegible]	[illegible]	(1)	(<1)	(30)	(25)
Pollen	<1		45	25		1		<1		30	25
Spores	<1		<1	<1		<1		<1		<1	<1
Paper	<1	<1	<1	<1		<1		<1			<1
Starch	<1							<1			
Misc. plant tissue	<1	<1	2	<1		<1		1			<1
Miscellaneous	(1)	(1)	(<1)	(5)	(<1)	(1)	(<1)	(1)	(<1)	(<1)	(5)
Iron or steel	<1	<1	<1	<1		<1		<1		<1	<1
Rubber	1	1		5		1		1			5

Table 68. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN WASHINGTON, D.C.

No. of filters	25	
	Quantity, percent	
Components	Average	Range
Minerals	(70)	39-87
Quartz	31	15-60
Calcite	15	5-45
Feldspars	3	2-4
Hematite	20	10-50
Mica	<1	
Other	<1	
Combustion Products	(23)	5-49
Soot:		
Oil	13	2-30
Coal	3	<1-5
Misc. soot		
Glassy fly ash	7	<1-20
Incinerator fly ash	<1	
Burned wood	<1	
Burned paper	<1	
Magnetite		
Carbon black		
Other		
Biological Material	(5)	<1-47
Pollen	4	<1-45
Spores	<1	
Paper	<1	
Starch	<1	
Misc. plant tissue	1	0-3
Leaf trichomer		
Miscellaneous	(2)	<1-25
Iron or steel	<1	
Rubber	2	0-25
Other	<1	0-10

CHATTANOOGA

The City of Chattanooga is located in Hamilton County in the southeastern portion of Tennessee along the Tennessee-Georgia state line. The important features of Hamilton County are the Tennessee River and river valley and the ridges, mountain ranges, and valleys which run in a northeast to southwest direction. Chattanooga is surrounded by Lookout Mountain to the southwest which is 1,200 feet higher than the city, the river and several ridges to the west to north and Missionary Ridge to the east. A more detailed discussion of the city is presented in Volume VIII.

Hamilton County lies near the center of the geographical region having the maximum high air pollution potential forecast days for the eastern United States. Dispersion is generally poor because the terrain tends to reduce wind speeds and enhance the frequency of occurrence of low-level temperature inversions. Chattanooga has a moderate climate and moderately heavy rainfall, averaging 52 inches per year. There is a high degree and a wide variety of heavy industrial activity, much of which is concentrated along the Tennessee River.

Five of the 12 monitors exceeded the national annual primary standard of 75 $\mu g/m^3$; the 24-hour primary standard was exceeded on 5 days (0.9 percent) at the site near the quarry and the 24-hour secondary standard was exceeded on 48 sampling days (6.9 percent) at eight of the sites. Air quality has been improving since the 1960's - geometric mean TSP concentrations decreased 110 $\mu g/m^3$ at the NASN site in the center city. An average decrease of 21 $\mu g/m^3$ occurred from 1971 to 1974 at three center city sites.

The locations of the six sites that were selected for filter analysis in Chattanooga are shown in Figure 15. Table 69 details the pertinent characteristics of these sites, and Table 70 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 71. The results for each of the 21 filters submitted for routine analysis are presented in Table 72. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 73. Seven filters underwent replicate analyses, and the results are presented in Table 74.

The composite particulate characterization for all filters from Chattanooga that underwent routine analysis, presented in Table 75, shows that there are nearly equal amounts of minerals and combustion products, a very unusual observation. In all other study cities the mineral components comprised more than half of the observed particles, while in Chattanooga it averaged only about one third. There was an expection, however, at the Shallowford Road site where 96 percent of the material was mineral matter (nearly all calcite). This was undoubtedly the result of the local influence of a nearby quarry and trucking activities.

Chattanooga was ranked high (third highest) in average percent combustion products. The principal combustion product identified was coal soot with a lesser amount identified as incinerator fly ash. The presence of products related to coal combustion is understandable in view of the high coal consumption in the area. The material identified as incinerator fly ash is suspected of being the result of the many diverse industrial processes (coking, smelting, founding, mineral products industries, etc.) prevalent in Chattanooga.

Biological materials were also very high in the area with Chattanooga averaging three times as much as any other study city. The Brainerd site averaged the highest percent biologicals but nearly all filters that were examined from April to May showed substantial levels of pollen and miscellaneous plant tissue. Chattanooga also ranked high in average percent rubber (13 percent) with only one other city recording higher levels. The Broad Street site, which is located near a heavily traveled highway, averaged 20 percent rubber. Lesser but still significant amounts of rubber were found at the City Hall and Brainerd. It is interesting to note the extremely high levels of rubber observed on December 13, 1974 at City Hall and Brainerd. If the microscopy results are a reliable indicator of the makeup of all the particulate collected on the hi-vol filters, then the rubber concentration at City Hall and Brainerd on that date would be 41 $\mu g/m^3$ and 54 $\mu g/m^3$, respectively.

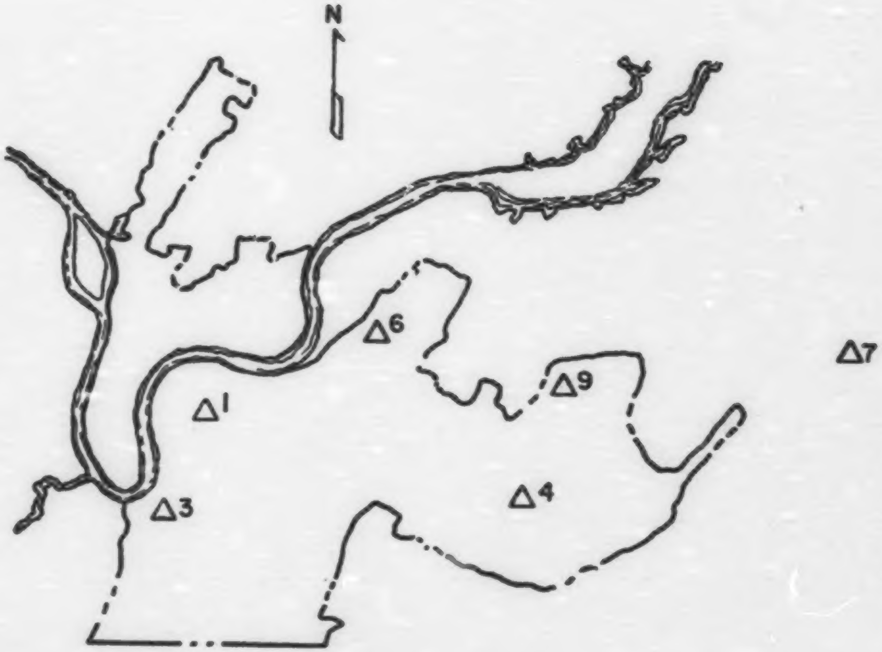

Figure 15. Chattanooga TSP monitoring sites selected for filter analysis

Table 69. SAMPLING SITE DESCRIPTIONS

Site number		1974 TSP geometric mean, $\mu g/m^3$	Predominant influence	Land use	Height above ground, feet
1	City Hall Annex	80	Center city	Commercial-surrounding; train yard - W 1000 feet, S and SE 500 feet; flour mill - ESE 3000 feet; industrial area - S 1 mile.	50
3	WDEF, Broad St.	86	Industrial	Foundries - N 1500 feet; industrial area - surrounding; heavy traffic on street - W 100 feet; Lookout Mt. - SW 1/2 mile.	30
4	Brainerd, Shawnee Trail	60	Residential	Residential-surrounding	3
6	East Chattanooga	81	Residential-Industrial	Residential and commercial - surrounding; train yard - W to NW 3000 feet; supermarket incinerator - SW 300 feet; medium traffic on-street - E 60 feet; nearby streets - no curbs or gutters.	25
7	Silverdale	38	Undeveloped	Forest-surrounding; industrial park (fertilizer, munitions) - NW 1-1/2 miles.	30
9	Shallowford Rd.	101	Industrial	Quarry - W 2000 feet; batching plant, truck terminals - surrounding, with some unpaved roads.	12

Table 70. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (LOVELL FIELD, CHATTANOOGA)

Date	Precipitation (in.)		Wind speed (mph)		Wind direction (deg)	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
4/11/74	0	0	10.1	10.0	C, C, C, 170 160, 170, 100, 100	180
4/29/74	0	0	6.5	5.9	C, C, C, 80 140, 100, 70, 60	250
5/11/74	0.46	0.36	6.8	3.6	40, 70, 50, 150 180, 180, 50, 100	110
10/26/74	0	0	1.7	0.9	C, C, C, C 230, 350, C, C	310
12/13/74	0	0	2.6	1.5	170, C, C, 220 80, 160, 250, C	170
12/31/74	0.02	0.03	5.8	5.7	C, C, C, C 30, 20, 20, 30	210

Note: C = Calm

Table 71. ANNUAL AVERAGE CONCENTRATION OF SULFATE AND NITRATE IONS AT THE CHATTANOOGA, TENNESSEE NASN SITE NO. 440380001 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	12.84	10.39	2.28	2.10
1973	11.64[a]	10.48[a]	2.54[a]	2.02[a]
1974	11.43[a]	10.88[a]	3.04[a]	2.79[a]

[a] Indicates insufficient data for statistically valid year.

Table 72a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CHATTANOOGA AND VICINITY (CITY HALL - NO. 1)

	11 April 1974			29 April 1974			11 May 1974			26 October 1974			13 December 1974			31 December 1974		
TSP (μg/m^3)	140			165			80			128			106			95		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(4)			(3)			(5)			(5)			(2)			(4)		
Quartz	1-	10-30	20	1	2-10	8	1+	5-25	10	3	1-40	5						
Calcite	2	10-40	20				2	5-40	20	1	5-30	20	1	4-20	8	2	10-60	40
Feldspars	2-	5-50	25	2	1-30	10	1+	2-50	20	1	2-50	15	1-	2-30	12	1-	5-40	30
Hematite																1	5-50	30
Mica																		
Coal																		
Combustion Products	(2)			(2+)			(3)			(4-)			(3)			(5)		
Soot																		
Oil							1-	10-30	25	1	10-20	30				1-	20-40	30
Coal	1	2-40	20	1+	2-70	30	1	5-50	25	1	20-80	40	1+	5-30	20	1+	10-80	60
Glassy fly ash																		
Incinerator fly ash	1-	5-70	35	1	5-50	20	1	10-100	40	2-	10-70	30	1+	10-80	40	3-	10-70	40
Burned wood																		
Burned paper																		
Magnetite																		
Biological Materials	(2)			(4)			(2-)			(1-)			(1)			(1)		
Pollen	1+	20-50	40	2-	20-60	35	1	20-40	25									
Spores																		
Paper																		
Starch				1-	8-15	10							1-	8-14	10	1-		
Misc. plant tissue				2-	200-500	400										1-		
Miscellaneous	(2)			(1)			(1-)			(1-)			(4)			(1-)		
Iron or steel													1-	5-30	10	1-	5-20	12
Rubber	2	20-100	70	1-	20-150	60	1-	20-100	60	1-	20-80	50	3+					

Table 72b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CHATTANOOGA AND VICINITY (BROAD STREET - NO. 3)

	11 April 1974			29 April 1974			11 May 1974			26 October 1974			13 December 1974			31 December 1974		
TSP (μg/m^3)	112			139			99			166			119			83		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(3)			(2+)			(1)			(2)			(2+)			(2)		
Quartz	1	25-70	50	1	2-30	15				1-	5-50	20				1	5-25	15
Calcite	1-	10-35	20	1	2-40	10				1-	5-10	8	1	5-30	15	1-	3-15	8
Feldspars	2-	5-75	30	1-	2-60	20				1	5-60	40	1	5-40	20			
Hematite																		
Mica																		
Coal																		
Combustion Products	(3)			(3+)			(6)			(7)			(3)			(6+)		
Soot																		
Oil	1-	5-50	30				1-	10-60	30	4-	20-200	60	1-	10-50	20	4	10-100	40
Coal	1+	5-75	50	2+	2-50	20	4	1-50	30	1	10-50	30	2-	5-75	40	1+	5-70	40
Glassy fly ash										1	5-15	10						
Incinerator fly ash	1-	10-150	50	1-	2-75	30	1+	1-100	40	2	1-200	80	1	5-100	40	1-	5-100	40
Burned wood																		
Burned paper																		
Magnetite																		
Biological Materials	(3+)			(3)			(1-)			(0+)			(0+)			(0+)		
Pollen	2+	20-60	40	2	15-45	30	1-	20-40	25									
Spores																		
Paper																		
Starch																		
Misc. plant tissue	1-			1	long													
Miscellaneous	(1-)			(1+)			(2+)			(1)			(4+)			(2)		
Iron or steel																		
Rubber	1-	20-75	40	1+	20-100	60	2+	5-100	50	1	10-150	100	4+	50-500	100	2		

Table 72c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CHATTANOOGA AND VICINITY (BRAINERD - NO. 4)

	11 April 1974			29 April 1974			11 May 1974			26 October 1974			13 December 1974			31 December 1974		
TSP($\mu g/m^3$)	113			68			37			207			95			48		
Components	Quantity, tenths	Size range, µm	Ave. size, µm	Quantity, tenths	Size range, µm	Ave. size, µm	Quantity, tenths	Size range, µm	Ave. size, µm	Quantity, tenths	Size range, µm	Ave. size, µm	Quantity, tenths	Size range, µm	Ave. size, µm	Quantity, tenths	Size range, µm	Ave. size, µm
Minerals	(4+)			(3)			(-)			(4)			(4)			(6+)		
Quartz	2-	10-40	20	1+	5-30	15				2	5-30	15	1-	5-20	12	1-	5-50	30
Calcite	2-	2-30	15	1	5-35	15				1	5-25	15	3-	1-20	6	2+	2-25	15
Feldspars	1	2-50	24	1-	2-25	10				1-	2-25	15	1	5-30	20	2	2-50	25
Hematite																1	2-60	20
Mica																		
Coal																		
Combustion Products	(2-)			(2)			(1)			(4)			(4)			(1)		
Soot																		
Oil				1-	10-40	25				1+	10-25	[illegible]	1-					
Coal	1-	10-75	40	1-	20-60	30				2-	10-50	30	2	2-40	10			
Fine soot										1	< 1-3	2	1	< 1-2	1.5			
Glassy fly ash																		
Incinerator fly ash	1-	10-100	30	1			1						1	2-40	30	1-	10-100	40
Burned wood																		
Burned paper																		
Magnetite																		
Biological Materials	(3)			(3)			(9)			(2)			(0+)			(2-)		
Pollen	2+	20-50	30	1+	30-50	35	1	8-60	30							1+	20-25	22
Spores																		
Paper																		
Starch																		
Misc. plant tissue	1-			1			8			1+	10-150							
Miscellaneous	(1)			(2)			(-)			(1-)			(1+)			(1)		
Iron or steel																		
Rubber	1	10-80	30	2						1-			1+	25-200	100	1		

Table 72d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CHATTANOOGA AND VICINITY (EAST CHATTANOOGA — NO. 6, SILVERDALE — NO. 7 AND SHALLOWFORD ROAD — NO. 9)

Site	East Chattanooga - No. 6			Silverdale - No. 7			Shallowford Road - No. 9		
Date	13 December 1974			26 October 1974			11 April 1974		
TSP (μg/m^3)	179			38			292		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(5)	< 1-30	7	(2)	< 1-20	6	(10-)	< 1-40	8
Quartz	1			1+					
Calcite	4						9+		
Feldspars									
Hematite									
Mica									
Coal									
Combustion Products	(5)	< 1-140	8	(8)	< 1-21	4	(0+)		
Soot									
Oil									
Coal	3+								
Glassy fly ash	1+			8-					
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Materials	(0+)			(0+)			(0+)		
Pollen									
Spores									
Paper									
Starch									
Misc. plant tissue									
Miscellaneous	(0+)			(0+)			(1-)		
Iron or steel									
Rubber									

Table 73. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN CHATTANOOGA AND VICINITY

Site	City Hall No. 1		Broad Street No. 3		Brainerd No. 4		East Chattanooga – No. 6	Silverdale No. 7	Shallowford Rd. – No. 9
No. of filters	6		6		6		1	1	1
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	Quantity, percent	Quantity, percent
Components	Average	Range	Average	Range	Average	Range	–	–	–
Minerals	(39)	22-52	(21)	9-31	(37)	3-63	(48)	(21)	(96)
Quartz	13	2-30	6	2-10	11	<1-20	8	14	3
Calcite	11	3-20	6	2-12	15	2-26	40	3	93
Feldspars	13	6-18	7	2-16	9	1-20			
Hematite	2	Tr- 3	2	1-3	2	0-12		1	
Other		0- 1		0-Tr				3	
Combustion Products	(31)	19-48	(48)	28-71	(22)	8-42	(51)	(78)	(1)
Soot									1 (vf)
Oil	4	0-12	15	Tr-40	5	0-13	3		
Coal	13	8-15	20	10-40	9	Tr-18	34	2	
Glassy fly ash		0- 2	2	0- 5	1	0- 3	13	76	
Incinerator fly ash	14	5-26	11	6-20	7	0-11			
Other							1		
Biological Materials	(16)	6-39	(11)	0-33	(31)	2-90	(<1)	(<1)	(<1)
Pollen	7	Tr-16	8	0-25	10	Tr-25			<1
Spores		0- 1		0-Tr	1	0- 2		Tr	
Paper	1	Tr- 2		0- 2	1	0- 2		<1	
Starch	3	1- 5		0-Tr		0- 1	<1		
Misc. plant tissue	5	1-17	3	Tr- 8	19	Tr-80			Tr
Miscellaneous	(14)	4-39	(20)	8-45	(10)	0-20	(<1)	(Tr)	(4)
Iron or steel	1	0- 4		0		0	<1	Tr	
Rubber	13	4-35	29	8-45	10	Tr-20		Tr	4

Table 74. RESULTS OF REPLICATE ANALYSES OF CHATTANOOGA FILTERS

Site	City Hall - No. 1							Broad Street - No. 3			E. Chattanooga No. 6		Silverdale No. 7		Shallowford Road - No. 9	
Date	29 April 1974			11 May 1974		31 December 1974		29 April 1974			13 December 1974		26 October 1974		11 April 1974	
TSP ($\mu g/m^3$)	165			80		95		139			179		38		292	
Laboratory	A		B	A	B	A		A		B	A		A		A	
Analysis	1	2	1	1	1	1	2	1	2	1	1	2	1	2	1	2
Components																
Minerals	(32)	(74)	(45)	(48)	(25)	(40)	(69)	(24)	(74)	(39)	(48)	(56)	(21)	(82)	(96)	(96)
Quartz	8	20		15		20	30	9	10		8	15	14	40	3	3
Calcite	3	40		18		6	30	8	50		40	35	3	30	93	90
Feldspars	18	4		15		12	4	6	4			4		2		1
Hematite	3	10		tr		<1	5	1	10			2	1	10		2
Mica				tr		1		tr						<1		
Coal						1										
Other													3			
Combustion Products	(23)	(16)	(52)	(30)	(74)	(48)	(30)	(34)	(16)	(60)	(51)	(42)	(78)	(17)	(1)	(4)
Soot:																
Oil	tr	10	15	7	31	4	25	tr	10	34	3	40		15		4
Coal	13	2		12		15	2	25	2		34	1	2	<1		<1
Very fine						[illegible]									1	
Glassy fly ash	tr	4	37	2	43		3	3	4	26	13	1	76	2		<1
Incinerator fly ash	10			9		26		6								
Burned wood																
Burned paper												<1		<1		
Magnetite											1					
Biological Material	(39)	(7)	(3)	(16)	(1)	(8)	(<1)	(28)	(5)	(<1)	(<1)	(<1)	(<1)	(<1)	(<1)	(<1)
Pollen	16	5		12		<1	<1	18	5			<1		<1	<1	<1
Spores	tr	<1		tr			<1		<1			<1	tr	<1		
Paper	1	<1		1		tr	<1	2	<1			<1	<1	<1		
Starch	5	<1		2		4	<1		<1		<1	<1		<1		
Misc. plant tissue	17	2		2		4	<1	8	<1			<1		<1	tr	<1
Miscellaneous	(6)	(5)	(<1)	(6)	(<1)	(4)	(1)	(14)	(5)	(<1)	(<1)	(2)	(tr)	(1)	(4)	(<1)
Iron or steel		<1							<1		<1	<1	tr	<1		<1
Rubber	6	5		6		4	1	14	5			2		1	4	<1

Table 75. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN CHATTANOOGA

No. of filters	21	
	Quantity, percent	
Components	Average	Range
Minerals	(36)	3-96
Quartz	10	<1-30
Calcite	16	2-93
Feldspars	8	0-20
Hematite	2	0-12
Mica		
Other	<1	0-3
Combustion Products	(35)	8-78
Soot:		
Oil	7	0-40
Coal	14	0-40
Misc. soot		
Glassy fly ash	5	0-76
Incinerator fly ash	9	0-26
Burned wood		
Burned paper		
Magnetite		
Carbon black		
Other		
Biological Material	(16)	0-90
Pollen	7	0-25
Spores	<1	0-2
Paper	<1	0-2
Starch	1	0-5
Misc. plant tissue	8	0-80
Leaf trichomer		
Miscellaneous	(13)	0-45
Iron or steel	<1	0-4
Rubber	13	0-45
Other		

OKLAHOMA CITY

Oklahoma City is an institutional, light-industrial city located in slightly rolling hills in the center of Oklahoma. The major fuel is natural gas, and the biggest industrial categories are electric equipment manufacture and food and agriculture products. The Oklahoma City area receives less precipitation than is typical of the northeastern portion of the country, but is fairly well vegetated and is not truly arid. Precipitation comes primarily in the spring and summer, much of it in occasional heavy thunderstorms. Wind speeds are generally high, averaging 12 to 15 miles per hour. There is a generally prevailing flow from the south, except during January and February when northerly breezes predominate. Dust storm type conditions occur but air quality data taken during such conditions are discounted. A more detailed discussion of the city is presented in Volume IX.

During 1974, five of the 14 sites had levels above the primary standard, one was above the secondary standard, and the other eight sites has TSP levels below 60 $\mu g/m^3$. The five sites not attaining the primary standard include three (Nos. 15, 17, 22) of the four located in the central business area, one (No. 18) that is fairly central and subject to heavy traffic, and one suburban site (No. 14) subject to the influence of immediately local construction.

The locations of the 11 sites that were selected for filter analysis in Oklahoma City are shown in Figure 16. Table 76 details the pertinent characteristics of these sites, and Table 77 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 78. The results for each of the 27 filters submitted for routine analysis are presented in Table 79. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 80. Three filters underwent replicate analyses, and the results are presented in Table 81.

The composite particulate characterization for all filters from Oklahoma City that underwent routine analysis, presented in Table 82, shows that minerals, principally calcite and quartz, overwhelm the suspended particulate material. Oklahoma City ranked highest of the 14 study cities in percent minerals, averaging 88 percent citywide. The only site that showed any substantial deviation from the citywide trend was the Southwest 2nd and Robinson location (No. 22) which also recorded the highest TSP levels of all sites in 1974. That site averaged 72 percent minerals and a high 18 percent rubber. The high rubber values observed are no doubt caused by the heavy vehicular traffic on the nearby expressway and ramp. In fact on the filter from October 11, 1974 rubber particles as long as 500 μm were observed which would indicate a very local source. Oddly, on that same day rubber particles as long as 300 μm were observed on the filter from the 200 North Walker site (No. 1) which is located 70 feet above grade.

The Oklahoma City-County Health Department, Environmental Health Services, Division of Air Quality Control, runs monthly composited analyses for lead and cadmium at each monitoring site. The monthly and annual values for lead, presented in Table 83, substantiate the influence of vehicular traffic at some sites. The highest average lead concentration occurred at site 22, where large amounts of rubber were also observed. The second highest lead levels were observed at site 18 which is also suspected of being heavily influenced by traffic.

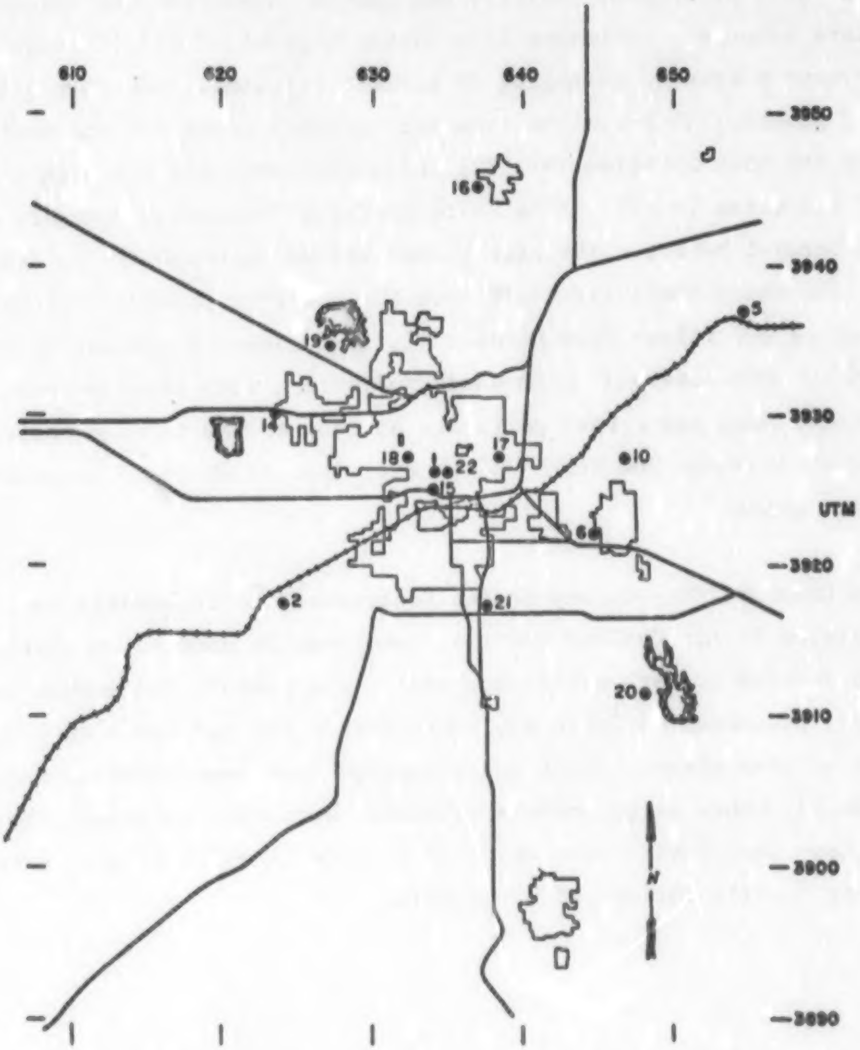
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Figure 16. Locations of monitoring sites in Oklahoma City

Table 76. OKLAHOMA CITY HI-VOL SITES

SAROAD code	Local code no.	City	Address	Site characteristics	Height above ground, feet	Comments/influences	1974 geometric mean TSP
37 2200 001 F02	1	Oklahoma City	200 N. Walker	CBD	70	High office bldg; near urban renewal	55
37 2200 002 F02	2	Oklahoma City	S.W. 66th and Denning	Rural	14	Airport to east; agriculture to west	41
37 2180 005 F03	5	Jones	S.W. First and Main	Rural	14	Agriculture to south	39
37 1940 010 F01	10	Midwest City	N.E. 10th and Douglas	Suburban	14	Suburban fire station	49
37 0260 014 F01	14	Bethany	3919 N. Rockwell	Suburban	4	On grass; construction nearby	80
37 2200 015 F02	15	Oklahoma City	428 W. California	CBD	15	Downtown fire station; higher buildings near	92
37 2200 017 F02	17	Oklahoma City	800 N.E. 13th & Phillips	CBD	15		89
37 2200 018 F02	18	Oklahoma City	2045 N.W. Tenth	CBD	8	Heavy traffic; stop-go on arterials	98
37 2200 019 F03/1	19	Oklahoma City	N.W. Highway & Meridian	Suburban	15	Open fields; traffic and shopping center distant	62
37 2200 021 F03/1	21	Oklahoma City	S.E. 74th and Highway	Suburban	15	Near expressway	54
37 3300 022 F02/1	22	Oklahoma City	S.W. Second & Robinson	CBD	12	Heavy traffic; expressway and ramp	107

Table 77. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (WILL ROGERS WORLD AIRPORT, OKLAHOMA CITY)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg.	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
5/09/74	0	0	11.8	11.0	140, 160, 140, 180 200, 190, 180, 150	180
6/29/74	0	0	16.5	15.5	150, 150, 170, 200 200, 180, 150, 180	180
7/16/74	0	0	5.8	3.8	C, 210, 320, 140 140, 160, 120, 120	140
10/11/74	0	0	13.2	13.0	150, 150, 150, 160 180, 170, 150, 160	160
10/18/74	0	0	10.2	9.6	320, 340, 320, 310 340, 360, 360, 10	340
12/16/74	0	0	10.9	9.8	350, 310, 330, 310 320, 330, 340, 220	320

Note: C = Calm

Table 78. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE OKLAHOMA CITY, OKLAHOMA, NASN SITE NO. 372200015 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	6.65	5.85	2.98	2.62
1973	4.35[a]	4.00[a]	1.78	1.42
1974	4.59[a]	3.33[a]	2.91	1.94

[a] Indicates insufficient data for statistically valid year.

Table 79a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (200 NORTH WALKER — NO. 1 AND S.W. 66th AND DENNING — NO. 2)

Site	200 North Walker - No. 1									S. W. 66th and Denning - No. 2								
Date	16 July 1974			11 October 1974			16 December 1974			9 May 1974			29 June 1974			18 October 1974		
TSP ($\mu g/m^3$)	92			70			46			38			206			55		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9)			(8)			(8+)			(9-)			(9+)			(9-)		
Quartz	1+	<1-70	2	3	<1-100	2	5	<1-100	1	2	<1-60	2	4	<1-60	3	2+	<1-80	2
Calcite	6	<1-70	2	3+	<1-150	2	2+	<1-70	2	5+	<1-60	2	3+	<1-30	3	5	<1-80	2
Feldspars	1-			1-			1-											
Hematite	1	<1-15	0.5	1	<1-50	0.5	1-	<1-20	0.5	1	<1-20	0.5	1+	<1-40	0.5	1	<1-20	0.5
Mica																		
Combustion Products	(1)			(1-)			(1)			(1)			(1-)			(1)		
Soot:																		
Oil	1-	1-50	0.5				1-			1-	<1-20	0.5				1-		
Coal	1-															1-		
Glassy fly ash																		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(1-)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(1+)			(1)			(0+)			(0+)			(1-)		
Iron or steel																		
Rubber				1+	<1-300	50	1	<1-250								(1-)		

Table 79b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (BETHANY – NO. 14 and N.E. 13th AND PHILLIPS – NO. 17)

Site	Bethany -- No. 14									N.E. 13th and Phillips – No. 17								
Date	9 May 1974			29 June 1974			18 October 1974			9 May 1974			29 June 1974			18 October 1974		
TSP ($\mu g/m^3$)	165			238			73			119			224			116		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9+)			(10)			(8+)			(9+)			(9+)			(10)		
Quartz	4+	<1-75	3	6+	<1-150	2	1+	<1-50	2	2+	<1-50	2	2	<1-70	2	3+	<1-50	2
Calcite	3+	<1-50	3	1+	<1-150	2	6	<1-50	3	6	<1-50	3	4	<1-50	3	5	<1-50	2
Feldspars	1-			1-			1-			1-			1-			1-		
Hematite	1	<1-40	0.5	1+	<1-100	0.5	1-	<1-10	0.5	1-	<1-25	0.5	3	<1-30	0.5	1	<1-20	0.5
Mica																		
Combustion Products	(1-)			(0+)			(1)			(1-)			(1-)			(0+)		
Soot:																		
Oil	1-	<1-60	0.5				1-			1-								
Coal							1-											
Glassy fly ash																		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(1-)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber							1-	<1-50	10									

Table 79c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (2045 N.W. 10th — NO. 18 AND N.W. HIGHWAY AND MERIDIAN — NO. 19)

Site	2045 N.W. 10th — No. 18									N.W. Highway and Meridian — No. 19								
Date	9 May 1974			29 June 1974			18 October 1974			16 July 1974			11 October 1974			16 December 1974		
TSP ($\mu g/m^3$)	97			202			123			83			49			46		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(9)			(10)			(7)			(9+)			(8+)			(9)		
Quartz	1+	<1-100	2	1+	<1-100	2	2+	<1-50	1	2	<1-50	2	5+	<1-100	2	2+	<1-60	2
Calcite	6	<1-100	2	7+	<1-160	2	2+	<1-50	3	6	<1-50	2	2	<1-100	2	5	<1-60	2
Feldspars													1-			1-		
Hematite	1	<1-50	0.5	1-	<1-20	0.5	1+	<1-30	0.5	1+	<1-20	0.5	1-	<1-20	0.5	1	<1-10	0.5
Mica																		
Combustion Products	(1-)			(0+)			(3)			(1-)			(1)			(1)		
Soot:																		
Oil							2+			(1-)			1-			1-	<1-20	
Coal													1-					
Glassy fly ash																		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1-)			(0+)			(0+)			(0+)			(1-)			(0+)		
Iron or steel																		
Rubber	1-	1-100	40										1-	<1-50	8			

Table 79d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (S.E. 74th AND HIGH — NO. 21 AND S.W. 2nd AND ROBINSON — NO. 22)

Site	S.E. 74th and High — No. 21									S.W. 2nd and Robinson — No. 22								
Date	16 July 1974			11 October 1974			16 December 1974			16 July 1974			11 October 1974			16 December 1974		
TSP ($\mu g/m^3$)	66			71			53			141			126			118		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9)			(9+)			(9)			(8+)			(6+)			(7)		
Quartz	2+	<1-	2	4	<1-100	2	2+	<1-60	2	1	<1-100	2	1	<1-150	3	2	<1-100	5
Calcite	4+	<1-	2	4	<1-100	2	5	<1-60	2	5+	<1-100	2	4+	<1-150	3	3+	<1-100	5
Feldspars	1-			1-			1-			1-						1-		
Hematite	1+	<1-20	0.5	1	<1-30	0.5	1	<1-10	0.5	1+	<1-30	0.5	1-	<1-	0.5	1	<1-100	0.5
Mica																		
Combustion Products	(1)			(1-)			(1)			(1)			(1-)			(1)		
Soot:																		
Oil	1	<1-50	0.5				1	<1-25	0.5	1-	<1-60	0.5				1-		
Coal																1-		
Glassy fly ash																		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(1-)			(3)			(2)		
Iron or steel																		
Rubber										1-			3	<1-500	50	2	<1-150	30

Table 79e. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (JONES – NO. 5, N.E. 10th AND DOUGLAS – NO. 10, AND 428 W. CALIFORNIA – NO. 15)

Site	Jones – No. 5			N.E. 10th and Douglas – No. 10			428 W. California No. 15		
Date	29 June 1974			29 June 1974			29 June 1974		
TSP, ($\mu g/m^3$)	53			119			237		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(10)			(9+)			(9+)		
Quartz	6	<1-100	2	1+	<1-70	2	5+	<1-200	3
Calcite	2+	<1-150	2	7	<1-70	2	3+	<1-200	3
Feldspars	1-								
Hematite	1	<1-30	0.5	1	<1-30	0.5			
Mica									
Combustion Products	(0+)			(1-)			(1-)		
Soot:									
Oil				1-					
Coal									
Glassy fly ash									
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Material	(0+)			(0+)			(0+)		
Pollen									
Spores									
Paper									
Starch									
Misc. plant tissue									
Miscellaneous	(0+)			(0+)			(0+)		
Iron or steel									
Rubber									

Table 80a. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY

Site	North Walker No. 1		S.W. 64th & Denning – No. 2		Bethany No. 14		N.E. 13th & Phillips No. 17		2045 N.W. 10th No. 18		N.W. Highway & Meridian No. 19	
No. of filters	3		3		3		3		3		3	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(84)	79-89	(89)	87-93	(93)	84-99	(95)	94-99	(85)	69-98	(89)	84-95
Quartz	32	15-50	28	20-40	42	15-65	26	20-35	18	15-25	33	20-55
Calcite	40	25-60	47	35-55	37	15-60	50	40-60	53	25-75	43	20-60
Feldspars	4	4	2	2-3	4	4	4	4	3	3-4	3	<1-4
Hematite	8	5-10	12	10-15	10	5-15	15	6-30	11	5-15	10	5-15
Mica			<1		<1	0-1	<1					
Combustion Products	(9)	6-11	(8)	7-9	(5)	1-10	(4)	1-6	(13)	2-31	(9)	5-11
Soot:												
Oil	4	2-6	4	3-6	3	1-5	3	1-4	10	2-25	6	4-8
Coal	3	2-4	3	2-4	1	<1-4	1	<1-1	2	<1-3	2	<1-4
Glassy fly ash	2	1-2	1	1-2	1	<1-2	<1	<1-1	1	<1-3	1	<1-2
Incinerator fly ash					<1		<1		<1			
Burned wood									<1			
Burned paper	<1		<1		<1		<1		<1			
Magnetite												
Biological Material	(<1)		(2)	<1-4	(<1)		(1)	<1-2	(<1)		(<1)	
Pollen			<1		<1		<1		<1			
Spores	<1		1	<1-2	<1		<1		<1		<1	
Paper	<1		<1		<1		<1		<1		<1	
Starch	<1		<1				<1					
Misc. plant tissue	<1		1	<1-?	<1		1	<1-2	<1		<1	
Miscellaneous	(7)	<1-15	(1)	<1-4	(2)	<1-6	(<1)		(2)	(<1-5)	(2)	<1-6
Iron or steel	<1		<1		<1		<1		<1		<1	
Rubber	7	0-15	1	0-4	2	0-6			2	0-5	2	0-6

Table 80b. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY

Site	S.E. 74th & High — No. 21		S.W. 2nd & Robinson No. 22		Jones — No. 5	N.E. 10th & Douglas No. 10	428 W. Calif. No. 15
No. of filters	3		3		1	1	1
	Quantity, percent		Quantity, percent		Quantity, percent	Quantity, percent	Quantity, percent
Components	Average	Range	Average	Range	—	—	—
Minerals	(91)	89-96	(72)	63-84	(99)	(96)	(93)
Quartz	30	25-40	13	10-20	60	15	55
Calcite	45	40-50	45	35-55	25	70	35
Feldspars	4	4	3	3-4	4	2	3
Hematite	12	10-15	10	5-15	10	9	
Mica							<1
Combustion Products	(9)	4-11	(9)	6-12	(1)	(4)	(7)
Soot:							
Oil	6	2-8	4	2-6	1	4	3
Coal	3	2-3	3	2-4	<1	<1	3
Glassy fly ash	<1	0-1	2	2	<1	<1	1
Incinerator fly ash			<1	0-1		<1	<1
Burned wood			<1				
Burned paper			<1				<1
Magnetite							
Biological Material	(<1)		(1)	(<1-1)	(<1)	(<1)	(<1)
Pollen	<1		<1			<1	<1
Spores	<1		<1		<1	<1	<1
Paper	<1		<1		<1	<1	<1
Starch			<1	0-1			<1
Misc. plant tissue	<1		1	<1-1	<1	<1	<1
Miscellaneous	(<1)		(18)	4-30	(<1)	(<1)	(<1)
Iron or steel	<1		<1		<1	<1	<1
Rubber	<1		18	4-30			

Table 81. **RESULTS OF REPLICATE ANALYSES OF OKLAHOMA CITY FILTERS**

Site	Bethany — No. 14				428 W. Calif. No. 15		
Date	29 June 1974		18 Oct. 1974		29 June 1974		
TSP ($\mu g/m^3$)	238		73		237		
Laboratory	A	B	A	B	A	A	B
Analysis	1	1	1	1	1	2	1
Components							
Minerals	(99)	(36)	(84)	(31)	(93)	(86)	(47)
Quartz	65		15		55	22	
Calcite	15		60		35	59	
Feldspars	4		4		3		
Hematite	15		5			4	
Mica					<1	<1	
Combustion Products	(1)	(64)	(10)	(53)	(7)	(10)	(29)
Soot:							
Oil	1	1	6	6	3		6
Coal	<1		4		3		
Unidentified soot						2	
Coal fly ash						5	
Glassy fly ash	<1	63	2	47	1	3	23
Incinerator fly ash			<1		<1		
Burned wood							
Burned paper					<1		
Magnetite							
Biological Material	(<1)	(<1)	(<1)	(16)	(<1)	(1)	(9)
Pollen			<1		<1	<1	
Spores	<1		<1		<1	<1	
Paper			<1		<1	<1	
Starch					<1		
Misc. plant tissue	<1		<1		<1	1	
Miscellaneous	(<1)	(<1)	(6)	(<1)	(<1)	(3)	(5)
Iron or steel	<1		<1		<1		
Rubber			6			3	

Table 82. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN OKLAHOMA CITY

No. of filters	27	
	Quantity, percent	
Components	Average	Range
Minerals	(88)	63-99
Quartz	29	10-65
Calcite	45	15-75
Feldspars	3	<1-4
Hematite	11	0-30
Mica	<1	
Other		
Combustion Products	(8)	1-31
Soot:		
Oil	5	1-25
Coal	2	<1-4
Misc. soot		
Glassy fly ash	1	0-3
Incinerator fly ash	<1	
Burned wood	<1	
Burned paper	<1	
Magnetite		
Carbon black		
Other		
Biological Material	(<1)	<1-4
Pollen	<1	
Spores	<1	<1-2
Paper	<1	
Starch	<1	0-1
Misc. plant tissue	<1	<1-2
Leaf trichomer		
Miscellaneous	(4)	<1-30
Iron or steel	<1	
Rubber	4	0-30
Other		

Table 83. MONTHLY AND ANNUAL LEAD CONCENTRATIONS FROM HI-VOL FILTERS IN OKLAHOMA CITY, OKLAHOMA FOR 1974, $\mu g/m^3$

Site No.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual arith-metic mean
1	1.41	1.24	0.67	0.43	0.62	0.61	0.70	0.47	0.45	1.16	0.42	0.46	0.72
2	0.33	0.17	0.13	0.12	0.17	0.14	0.22	0.11	0.14	0.15	0.07	0.11	0.18
5	0.34	0.13	0.10	0.10	0.14	0.12	0.14	0.07	0.21	0.27	0.23	0.17	0.17
6	0.83	0.41	0.40	0.52	0.34	0.39	0.52	0.39	0.65	0.39	0.38	0.36	0.47
10	0.87	0.46	0.45	0.61	0.26	0.38	0.75	0.47	0.49	0.44	0.42	0.43	0.50
14	0.94	0.28	0.40	0.34	0.38	0.41	0.54	0.39	0.65	0.37	0.25	0.30	0.44
15	2.22	2.21	0.95	1.49	0.92	1.11	1.27	1.88	1.77	1.08	1.01	0.84	1.40
16	2.38	0.52	0.32	0.41	0.40	0.48	0.49	0.68	0.51	0.51	0.27	0.26	0.60
17	0.48	0.51	0.39	0.44	0.31	0.39	0.53	0.39	0.62	0.34	0.56	0.43	0.45
18	0.94	1.43	1.47	1.78	1.23	1.60	1.67	1.54	1.92	1.99	1.28	1.20	1.50
19	1.19	0.86	0.45	0.61	0.58	0.53	0.87	0.78	0.67	0.74	0.32	0.35	0.66
20	0.19	0.19	0.11	0.12	0.11	0.13	0.15	0.12	0.11	0.27	0.12	0.14	0.15
21	0.58	0.57	0.29	0.29	0.29	0.28	0.46	0.30	0.26	0.53	0.35	0.31	0.38
22	2.13	1.82	1.67	1.59	1.02	1.22	1.83	1.61	1.39	2.36	0.86	0.98	1.54

SEATTLE

The Puget Sound Intrastate Air Quality Control Region (AQCR) encompasses the Counties of King, Kitsap, Pierce and Snohomish, and straddles the central part of Puget Sound, a large irregular mass of salt water containing numerous islands. On the east side of the AQCR is the 3000- to 6000-foot high Cascade Range, which effectively blocks the ventilation of the Puget Sound Lowlands in that direction. On the west side, the Olympic Mountains intercept a large part of the westerly rain-bearing winds. However, the winds can sweep freely north and south through the valley. The climate is predominantly midlatitude, west coast, with a dry, warm summer and a rather mild but wet winter. Precipitation averages less than 40 inches in the lowlands bordering Puget Sound.

Most of the population of the AQCR is located along a narrow, low-land corridor, mainly on the eastern side of the Sound. The industry of the area is also located along this strip, much of it being concentrated in the Duwamish Valley where fugitive dust is also prominent. Industry is oriented toward manufacturing and service activities, especially transportation equipment and forest-related industries. A more detailed discussion of the city is presented in Volume X.

Of those stations reporting a full year of data, the national primary annual air quality standard for particulates (75 $\mu g/m^3$) was exceeded at two stations in the industrial area of Seattle and the secondary annual standard (60 $\mu g/m^3$) was exceeded at another two sites — one in the industrial valley and one in the city. The highest annual geometric mean was 105 $\mu g/m^3$ at a site in the industrial valley which is being considered for relocation back away from the road. Violations of the 24-hour standards occurred five times for the primary and 41 times for the secondary standard out of a total of almost 700 observations in 1974.

The locations of the six sites that were selected for filter analysis in Seattle are shown in Figure 17. Table 84 details the pertinent characteristics of these sites, and Table 85 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 86. The results for each of the 23 filters submitted for routine analysis are presented in Table 87. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 88. Six filters underwent replicate analyses, and the results are presented in Table 89.

The composite particulate characterization for all filters from Seattle that underwent routine analysis, presented in Table 90, shows that minerals predominate but not to as great a degree as observed in many study cities. Only three cities had lower average percent minerals than Seattle. Quartz was the major mineral constituent observed (over half of the mineral content) followed by lesser but nearly equal amounts of feldspars and calcite. The DOE site, which recorded the highest TSP levels in 1974, showed somewhat larger than average amounts of minerals presumably because of its proximity to the highway.

The site with the lowest average percent minerals was the Public Safety Building (K-1) which seems to be consistent with the high sampler location (80 feet above ground). Oddly, this site also recorded the highest levels of rubber, an observation apparently inconsistent with the sampler location.

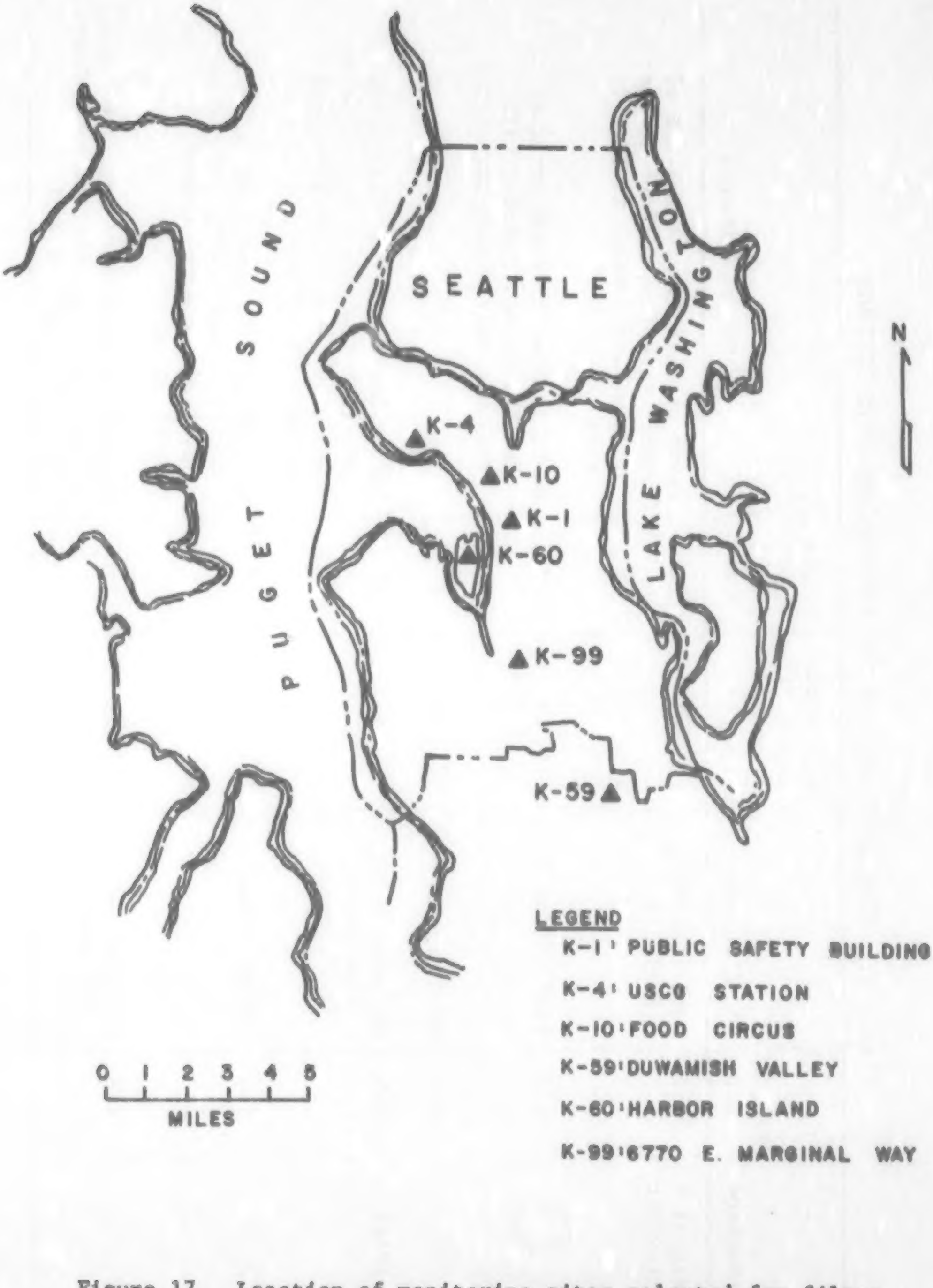

PUGET SOUND
SEATTLE
LAKE WASHINGTON
N
K-4
K-10
K-1
K-60
K-99
K-59
0 1 2 3 4 5
MILES
LEGEND
K-1: PUBLIC SAFETY BUILDING
K-4: USCG STATION
K-10: FOOD CIRCUS
K-59: DUWAMISH VALLEY
K-60: HARBOR ISLAND
K-99: 6770 E. MARGINAL WAY

Figure 17. Location of monitoring sites selected for filter analysis in Seattle

Table 84. CHARACTERISTICS OF SEATTLE MONITOR SITES REVIEWED

Neighborhood	PSAPCA No.	Location	1974 annual geometric mean, $\mu g/m^3$	Height above ground, feet	Siting comments
Commercial – Center City	K 1	Public Service Building	63	80	Seven stories rise to the NNW of monitor; 4-foot parapet 12 feet from monitor; heavy traffic in area
	K10	Food Circus	45	70	On hill above city and Duwamish Valley, in park; expect high readings only during inversions
	K 4	USCG Station	50	–	–
Industrial	K59	Duwamish Valley, 4500 Block E. Marginal	68	20	Openly located in industrial area, not source specific but probable influence from E. Marginal Way to east of monitor
	K60	Harbor Island	77	15	Well located in center of major industrial area; junky area to north, shipyards to east, cement plant to south, steel to SW
	K99	Duwamish Valley, DOE site	105	15	Possible interference from low trees 5 feet above monitor to west; heavy traffic volume to west

Table 85. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (SEATTLE-TACOMA AIRPORT)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour obs.	Resultant
6/10/74	0	0	8.1	6.6	20, 10, 350, 250 360, 310, 350, 20	360
6/28/74	0	t	5.6	3.2	120, 160, 200, 250 210, 240, C, 330	220
7/22/74	0	0	8.9	8.2	200, 160, 190, 220 220, 230, 230, 240	210
9/14/74	0	0	3.5	2.3	C, C, 300, 260 270, 290, C, 30	300
9/26/74	t	0	8.5	2.9	180, 130, 170, 220 160, 320, 340, 100	170
10/08/74	0	0	4.6	4.6	20, 10, 330, 10 290, 290, 30, C	350

Note: C = Calm
t = Trace

Table 86. ANNUAL AVERAGE CONCENTRATION OF SULFATE AND NITRATE IONS AT THE SEATTLE, WASHINGTON NASN SITE NO. 491840001 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	6.27	6.02	1.56	1.22
1973	6.69	6.53	2.36	2.09
1974	8.40[a]	8.19[a]	2.15[a]	1.94[a]

[a] Indicates insufficient data for statistically valid year.

Table 87a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN SEATTLE AND VICINITY (PUBLIC SAFETY BLDG. — NO. K-1 AND 6770 E. MARGINAL WAY — NO. K-99)

Site	Public Safety Bldg. — No. K-1									6770 E. Marginal Way — No. K-99								
Date	10 June 1974			14 Sept. 1974			26 Sept. 1974			22 July 1974			14 Sept. 1974			26 Sept. 1974		
TSP ($\mu g/m^3$)	54			117			126			101			115			163		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(3)			(3)			(6-)			(6)	<1-30	8	(8)	<1-45	14	(9-)	1-46	10
Quartz	1-	10-40	25	1+	5-40	20	2+	5-60	30	5+			6+			6		
Calcite							1	2-35	20				1-			1-		
Feldspars	2	5-40	25	1	2-50	20	1+	2-50	20							1		
Hematite							1-	1-15	7				1-			1		
Mica																		
Other													1-					
Combustion Products	(3-)			(6)			(3)			(0+)			(2)	<1-60	2	(1-)	<1-20	2
Soot:																		
Oil	2	5-100	25	2+	25-75	35	1-	5-75	35				2					
Coal																		
Glassy fly ash																		
Incinerator fly ash	1-	5-40	15	4-	50-300	150	2+	2-80	30									
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(2)		500	(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Leaf trichomes										2								
Miscellaneous	(4)			(1)			(1+)			(2)	5-90	28	(0+)			(1)	5-54	30
Iron or steel																		
Rubber	4	20-100	40	1	25-100	50	1+	10-150	60	2						1		

Table 87b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN SEATTLE AND VICINITY (HARBOR ISLAND — NO. K-60)

Date	10 June 1974			28 June 1974			22 July 1974			14 Sept. 1974			26 Sept. 1974			8 October 1974		
TSP ($\mu g/m^3$)	136			86			68			118			138			180		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(7+)			(5+)			(7)			(3+)			(3+)			(8)		
Quartz	4+	5-75	40	3+	5-100	40	3+	5-50	35	1	5-50	20	1	5-25	15	4	<1-100	3
Calcite	1	5-30	20	1-	2-50	30	1+	2-40	20	1	2-60	25	1	5-40	20	2	<1-100	3
Feldspars	1	2-40	20	1	5-100	40	1	2-60	30	1	2-40	20	1	2-60	30			
Hematite	1	1-30	10	1-	1-75	20	1	1-20	8	1-	2-15	10				1+	<1-60	0.5
Mica																		
Combustion Products	(2+)			(2+)			(2+)			(5)			(5+)			(1+)		
Soot:																		
Oil	1	40-60	50	1-	2-70	30	1-	15-75	40	1+	15-50	30	1-	15-55	30	1	<1-60	0.5
Coal	1	20-75	50	1	5-75	35	1	10-70	50	1-	5-70	30				1-		
Glassy fly ash																		
Incinerator fly ash	1-	2-70	30	1-	1-100	30				3	1-50	30	4+	1-60	30			
Burned wood																		
Burned paper																		
Magnetite				1-	5-70	20	1-	15-30	25				1-	5-30	20			
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(2+)			(1-)			(1)			(1)			(1-)		
Iron or steel																		
Rubber				1	25-75	40	1-			1	15-120	60	1	20-100	70	1-	<1-100	30
Silicate glass				1+	10-200	75												

Table 87c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN SEATTLE AND VICINITY (DUWAMISH VALLEY — NO. K-59)

Date	10 June 1974			28 June 1974			22 July 1974			14 Sept. 1974			26 Sept. 1974			8 October 1974		
TSP ($\mu g/m^3$)	66			45			27			90			62			110		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(4)			(7-)			(4)			(6)			(5+)			(8-)		
Quartz	2	2-45	20	5	5-50	20	2	5-25	15	4	5-50	35	2+	10-60	45	4+	<1-	2
Calcite	1-	2-30	15	1	2-40	20	1-			1-	5-35	20	1	5-30	25	1+	<1-	2
Feldspars	1	5-50	25	1-	2-50	20	2-	2-35	20	1	5-50	25	1+	5-50	35	1-		
Hematite																1	<1-20	0.5
Mica																		
Combustion Products	(3-)			(2)			(4+)			(3)			(3)			(2)		
Soot:																		
Oil	1-	5-30	15	1+	10-100	30	1	5-30	20	1	20-50	30				1	<1-60	0.5
Coal				1-	5-80	30	1	5-50	25	1+	5-60	30	2	5-50	25	1	<1-50	10
Fine soot							1+	<1-2	<1									
Glassy fly ash																		
Incinerator fly ash	2	2-75	30				1-	5-50	30	1-	5-75	30	1-	5-100	50			
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(2+)			(0+)			(1)			(0+)			(1-)			(0+)		
Pollen	2	20-50	25															
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1)			(1)			(1)			(1)			(1+)			(0+)		
Iron or steel																		
Rubber	1	10-70	40	1	40-150	70	1	20-100	60	1	10-90	35	(1+)	10-100	50			

Table 87d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN SEATTLE AND VICINITY (FOOD CIRCUS – NO. K-10 AND USCG STATION – NO. K-4)

Site	Food Circus – No. K-10												USCG Station – No. K-4		
Date	28 June 1974			22 July 1974			14 Sept. 1974			8 October 1974			8 October 1974		
TSP ($\mu g/m^3$)	39			41			78			95			90		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(5+)			(5)			(8)	1-60	6	(8-)			(9+)		
Quartz	1	5-35	15	2+	10-50	25	6			5	<1-80	1	6+	<1-70	2
Calcite	1	2-20	8	1-	2-15	8	1-			1+	<1-80	1	1+	<1-40	2
Feldspars	3	1-50	20	2	2-60	25							1-		
Hematite							1+			1	<1-15	0.5	1	<1-30	0.1
Mica															
Other							1-								
Combustion Products	(3+)			(3+)			(2)	<1-30		(2)			(1-)		
Soot:															
Oil	1	10-40	25	1+	10-100	25	1			1+	<1-60				
Coal	2	5-70	30							1-			1-		
Soot							1-								
Glassy fly ash							1-								
Incinerator fly ash	1-	40-70	50	1+	5-100	30									
Burned wood															
Burned paper															
Magnetite															
Biological Material	(1-)			(1-)			(0+)			(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(1)			(1)			(1-)			(0+)			(0+)		
Iron or steel															
Rubber	1	20-200	60	1	30-150										

Table 88. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN SEATTLE AND VICINITY

Site	Public Safety Bldg. — No. K-1		Harbor Island No. K-60		Duwamish Valley No. K-59		Food Circus No. K-10		6770 E. Marginal Way — No. K-99		USCG Station No. K-4
No. of filters	3		6		5		4		3		1
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	—
Minerals	(39)	30-56	(57)	33-78	(56)	41-76	(65)	51-78	(75)	60-87	(96)
Quartz	15	7-23	30	12-45	33	18-50	37	12-61	60	54-65	65
Calcite	5	2-12	11	8-20	9	5-15	9	5-15	4	1-7	15
Feldspars	15	12-20	9	3-12	10	4-16	13	0-28	3	0-8	4
Hematite	3	2-6	7	1-15	4	1-12	5	tr-10	5	2-9	12
Mica	<1	0-1	<1	0-1	<1	0-1	<1	0-1			<1
Coal			tr	0-tr							
Other							1		3	<1-4	
Combustion Products	(39)	27-62	(33)	17-55	(29)	22-43	(27)	18-34	(8)	1-20	(4)
Soot:											
Oil	17	5-25	9	5-15	9	2-15	12	8-15	7	0-20	
Coal			7	0-12	11	0-20	7	0-22			4
Very fine	<1	0-1	<1	0-1	3	0-16	<1	0-1			
Soot							1	0-5	1	0-1	
Glassy fly ash			<1	0-2	<1	0-2	1	0-4	tr	0-tr	<1
Incinerator fly ash	22	6-37	14	0-45	7	<1-20	5	0-14			<1
Burned wood			<1	0-tr							<1
Burned paper			<1	0-tr	tr	0-tr	<1	0-1			<1
Magnetite			3	0-6	tr	0-tr	<1	0-1			
Biological Material	(1)	tr-2	(1)	(tr-3)	(6)	tr-26	(2)	<1-5	(6)	<1-18	(<1)
Pollen	tr	0-tr	<1	0-1	4	0-20	1	tr-2	tr	0-tr	
Spores			tr	0-tr	<1	0-2	tr	0-tr	tr	0-tr	<1
Paper	1	0-2	<1	0-2	1	0-3	<1	0-1	tr	0-tr	<1
Starch	tr	0-tr	<1	0-2	<1	0-1	<1	0-1	tr	0-tr	
Misc. plant	tr	0-tr	tr	0-tr	1	0-2	1	0-1	tr	0-tr	<1
Leaf trichomes									6	0-18	
Miscellaneous	(21)	8-40	(9)	0-27	(9)	2-15	(6)	1-13	(11)	2-21	(<1)
Iron or steel			<1		<1	0-tr			1	0-2	<1
Rubber	21	8-40	7	tr-12	9	2-15	6	1-13	10	<1-20	
Silicate glass			2	0-15							
Other			<1	0-2							

Table 89. RESULTS OF REPLICATE ANALYSES OF SEATTLE FILTERS

Site	Public Safety Bldg. — No. K-1							USCG Station No. K-4		Harbor Island No. K-60		6770 E. Marginal Way — No. K-99	
Date	10 June 1974		14 Sept.1974		26 Sept. 1974			8 October 1974		8 October 1974		22 July 1974	
TSP ($\mu g/m^3$)	54		117		126			90		180		101	
Laboratory	A	B	A	A	A	A	B	A	B	A	A	A	A
Analysis	1	1	1	2	1	2	1	1	1	1	2	1	2
Components													
Minerals	(31)	(27)	(30)	(69)	(56)	(84)	(23)	(96)	(56)	(78)	(77)	(60)	(72)
Quartz	7		14	30	23	50		65		40	51	54	67
Calcite	12		2	25	12	20		15		20	8	1	2
Feldspars	20		12	4	14	4		4		3			
Hematite	2		2	10	6	10		12		15	18	2	3
Mica			tr		1	<1		<1					
Other						<1						3	
Combustion Products	(27)	(72)	(62)	(21)	(29)	(6)	(77)	(4)	(44)	(17)	(21)	(1)	(8)
Soot:													
Oil	20	46	25	15	5	6	23		14	10	18		
Coal				2		<1		4		4	3		
V.v.fine Soot	1											1	8
Glassy fly ash		26		3		<1	54	<1	30	2	<1		
Incinerator fly ash	6		37		24			<1		1			
Burned wood				1		<1		<1		<1			
Burned paper								<1		<1			
Magnetite													
Biological Material	(2)	(1)	(<1)	(<1)	(<1)	(<1)	(<1)	(<1)	(<1)	(<1)	(<1)	(18)	(8)
Pollen	tr			tr	tr	tr				tr		tr	
Spores				tr		tr		tr		tr		tr	
Paper	2			tr		tr		tr		tr			3
Starch			tr	tr							tr	tr	
Misc. plant tissues	tr			tr	tr	tr		tr		tr	tr		
Leaf trichomes												18	5
Miscellaneous	(40)	(<1)	(8)	(10)	(15)	(10)	(<1)	(<1)	(<1)	(5)	(<1)	(21)	(12)
Iron or steel				tr		tr		tr		tr	tr	1	<1
Rubber	40		8	10	15	10				5		20	12

Table 90. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN SEATTLE

No. of filters	23	
	Quantity, percent	
Components	Average	Range
Minerals	(60)	30-96
Quartz	35	7-65
Calcite	9	1-20
Feldspars	10	0-28
Hematite	5	1-15
Mica	<1	
Other	1	0-4
Combustion Products	(27)	1-62
Soot:		
Oil	10	0-25
Coal	6	0-22
Misc. soot	1	0-16
Glassy fly ash	<1	
Incinerator fly ash	9	0-45
Burned wood	<1	
Burned paper	<1	
Magnetite	1	0-6
Carbon black		
Other		
Biological Material	(3)	tr-24
Pollen	1	0-20
Spores	<1	0-2
Paper	1	0-3
Starch	<1	0-2
Misc. plant tissue	<1	0-2
Leaf trichomer	1	0-18
Miscellaneous	(10)	<1-40
Iron or steel	<1	0-2
Rubber	10	0-40
Other	<1	0-15

CINCINNATI

The City of Cincinnati is located in Hamilton County in the southwestern corner of the State of Ohio along the Indiana and Kentucky borders. The Ohio River forms the southern border of the county. Due to its location on the Ohio River and its proximity to the coal fields of West Virginia, Kentucky, Pennsylvania, and Ohio, Cincinnati has become an important transportation and manufacturing center. Cincinnati is located in a basin area of the Ohio River flood plain which is surrounded by steep bluffs cut by streams and rivers and rising 200 to 400 feet to the level of the upland plain.

There is a high degree and a wide variety of manufacturing activity, most of which is concentrated along the Ohio River and in the Mill Creek Valley and the Norwood Through. Cincinnati has a moderate climate, averaging 5070 heating degree days per year, and moderate rainfall, an average of 39 inches per year. Nocturnal inversions occur frequently in the valleys during the summer and fall. Extended periods of poor dispersion occur during the fall. A more detailed discussion of the city is presented in Volume XI.

Eight of the 25 sites in the county exceeded the national primary standard of 75 $\mu g/m^3$ and 13 other sites exceeded the secondary standard of 60 $\mu g/m^3$. The 24-hour primary standard was exceeded on two sampling days (0.1 percent) and the 24-hour secondary standard was exceeded on 61 sampling days (4.2 percent). Air quality has been improving for the past 10 years—annual geometric mean TSP concentrations decreased 70 $\mu g/m^3$ at the NASN site in the center city. An average decrease of 19 $\mu g/m^3$ occurred from 1970 to 1974 at the seven city sites that sampled during that time.

The locations of the four sites that were selected for filter analysis in Cincinnati are shown in Figure 18. Table 91 details the pertinent characteristics of these sites, and Table 92 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 93. The results for each of the 20 filters submitted for routine analysis are presented in Table 94. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 95. Five filters underwent replicate analyses, and the results are presented in Table 96.

The composite particulate characterization for all filters from Cincinnati that underwent routine analysis, presented in Table 97, shows that minerals predominate but that there is nearly an equal contribution from combustion products. In fact, Cincinnati had the highest average percent contribution of combustion products of all 14 study cities. A large portion of the combustion products is coal related (glassy fly ash, coal soot) which is reflective of the large industrial and utility use of coal.

It is somewhat perplexing that the site at the highest elevation above grade also had the highest average rubber content. Although the citywide average percent rubber was low compared to most other study cities, the Public Library site, which is 80 feet above grade, experienced as much as 20 percent rubber on one selected sampling day.

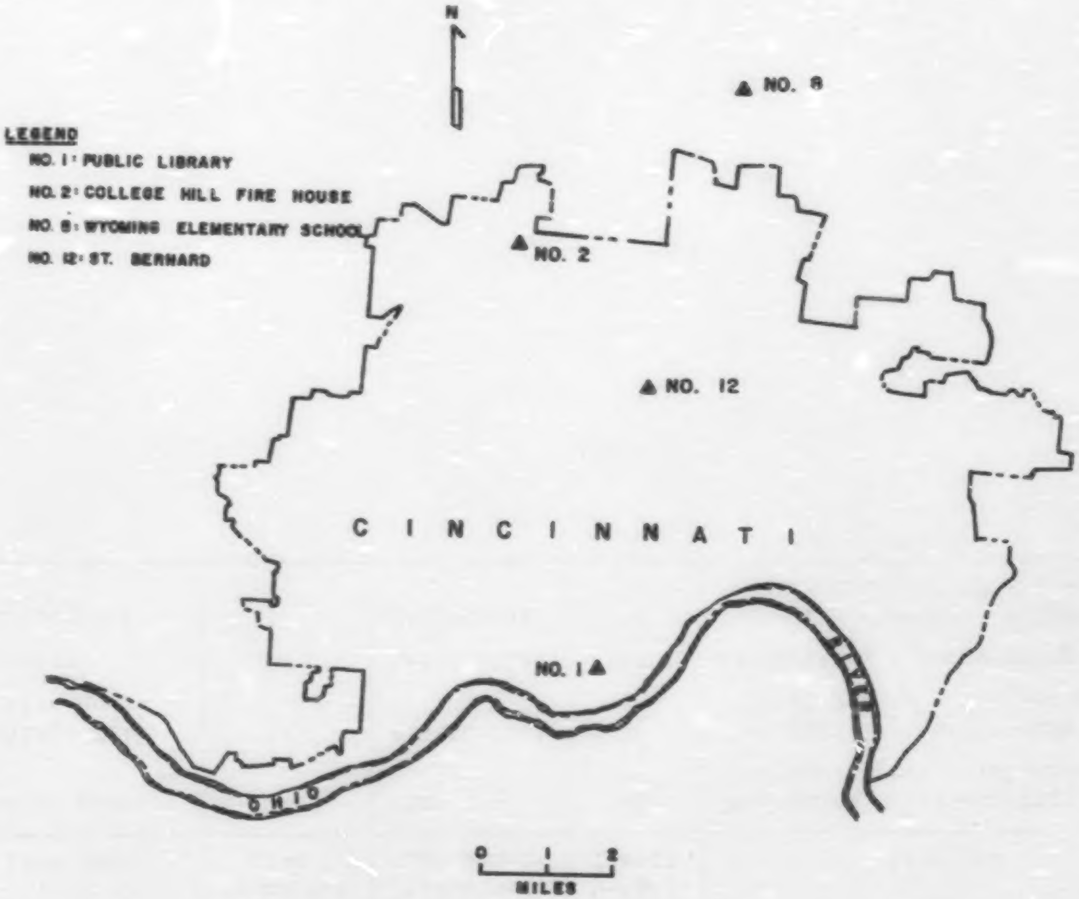

N
LEGEND
NO. 1: PUBLIC LIBRARY
NO. 2: COLLEGE HILL FIRE HOUSE
NO. 8: WYOMING ELEMENTARY SCHOOL
NO. 12: ST. BERNARD
NO. 8
NO. 2
NO. 12
CINCINNATI
NO. 1
OHIO
RIVER
0
1
2
MILES

Figure 18. Location of monitoring sites selected for filter analysis in Cincinnati

Table 9[illegible] SAMPLING SITE CHARACTERISTICS

Site number	Location	1974 TSP geometric mean	Predominant influence	Height (feet)	Land use
1	Public Library	75	CBD	80	Commercial – surrounding; urban renewal areas - 1/4 mile S and W
2	College Hill Fire House	57	Residential	30	Residential – surrounding; Mill Creek Valley - 3 miles SE
8	Wyoming	56	Residential	12	Residential – surrounding
12	St. Bernard	130	Industrial	16	Industry (chemical, shipping) – surrounding; I-75 - 1/4 mile SE

Table 92. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (GREATER CINCINNATI AIRPORT)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour obs.	Resultant
7/16/74	0	0.74	7.2	5.1	60, 70, 50, 90 80, 30, 40, 90	60
7/28/74	0	0	3.0	2.9	C, 230, 220, 230 260, 220, 240, C	230
8/13/74	0	0	6.8	5.8	50, 70, 80, 140 80, 120, 140, 120	100
10/08/74	0	0	4.0	1.2	40, 30, 60, 100 220, 160, 190, 210	160
10/26/74	0	0	4.5	3.4	20, 10, 40, 50 10, 310, C, 210	20
12/31/74	0.43	t	8.2	1.8	70, 90, 100, 120 100, 220, 270, 290	140

Note: C = Calm
t = Trace

Table 93. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE CINCINNATI, OHIO, NASN SITE NO. 361220001 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	11.98	11.36	3.71	3.54
1973	11.37[a]	10.43[a]	3.15[a]	2.92[a]
1974	12.42[a]	11.50[a]	3.47[a]	3.14[a]

[a] Indicates insufficient data for statistically valid year.

Table 94a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CINCINNATI AND VICINITY (PUBLIC LIBRARY - NO. 1)

Date	16 July 1974			28 July 1974			15 August 1974			8 October 1974			26 October 1974			31 December 1974		
TSP (μg/m^3)	102			142			130			128			88			50		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range μm	Avg. size, μm
Minerals	(4)			(4)			(3)			(3+)			(3)			(4+)		
Quartz	1	5-75	35	2+	5-40	20	2	2-40	15	1	5-30	10	1	5-40	25	1+	5-50	25
Calcite	2+	2-50	20	1-	2-30	15	1-	1-50	15	2	5-70	40	1	2-50	25	2	1-40	25
Feldspar	1-	2-35	15	1	5-50	20	1-	5-60	20	1-	5-50	20	1-	2-50	20	1	2-50	30
Hematite																		
Mica																		
Combustion Products	(4)			(5+)			(7)			(4+)			(6)			(4+)		
Soot:																		
Oil	1-	5-30	15	1-	5-70	20	1	5-150	40	1-	10-60	25	1	5-75	50	1	5-40	20
Coal	2	5-75	25	1-	5-70	25	1	5-75	30	2	2-50	20	1+	2-75	35			
Very fine																1-	<1- 3	1
Glassy fly ash				1+	2-50	15	5	5-50	15	1+	5-25	10	1+	2-25	15	2+	2-25	10
Incinerator fly ash	1	1-60	15	3	5-75	20				1-	2-50	20	2	2-60	35	1-	5-100	40
Burned wood																		
Burned paper																		
Magnetite																		
Biological Materials	(1-)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue	1-																	
Miscellaneous	(1+)			(1-)			(0+)			(2)			(1)			(1)		
Iron or steel																		
Rubber	1+	30-150	70	1-	20-100	50				2	10-100	40	1	25-100	75	1	20-100	60

Table 94b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CINCINNATI AND VICINITY (WYOMING ELEMENTARY SCHOOL – NO. 8)

Date	16 July 1974			28 July 1974			15 August 1974			8 October 1974			26 October 1974			31 December 1974		
TSP ($\mu g/m^3$)	89			130			106			84			58			49		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7-)			(7+)			(6+)			(8+)			(8-)			(2+)		
Quartz	2+	<1-50	5	1+	<1-30	3	2+	<1-70	5	2	<1-60	2	2+	<1-30	5	1	<1-25	5
Calcite	3	<1-50	5	1	<1-30	3	2+	<1-60	5	5	<1-60	2	4	<1-30	5	1	<1-25	5
Feldspar																		
Hematite	1	<1-10	0.5	4+	<1-200	30	1	<1-20	0.5	1	<1-15	0.5	1	<1-40	0.5			
Mica																		
Combustion Products	(3)			(3-)			(3)			(2-)			(2)			(7+)		
Soot:																		
Oil	1	<1-50	0.5	1	<1-40	0.5	2	<1-80	0.5	1+	<1-80	0.5	1+	<1-50	0.5	5	<1-100	0.5
Coal																		
Glassy fly ash	2	<1-100	5	1+	<1-30	10	1	<1-40	10				1-			2	<1-50	10
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(1-)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber							1-	1-80	20									

Table 94c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CINCINNATI AND VICINITY (ST. BERNARD – NO. 12)

Date	16 July 1974			28 July 1974			15 August 1974			8 October 1974			26 October 1974			31 December 1974		
TSP ($\mu g/m^3$)	170			204			172			240			125			84		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7)	<1-30	12	(4+)	2-80	8	(4+)	<1-45	12	(6)	<1-40	11	(9)	<1-25	7	(3)	<1-35	11
Quartz	4			2			1+			2			6+			1-		
Calcite	3-			1			3			4			2			2		
Feldspar																		
Hematite				1+									1-			1-		
Mica																		
Isotropic, brittle particles	1-																	
Combustion Products	(3)	<1-90	10	(5+)	<1-46	9	(5)	<1-45	11	(4)	<1-30	6	(1)	<1-28	6	(7)	<1-7	7
Soot:																		
Oil																		
Coal	1-			1-			1-			1-						1		
Unidentified soot													1					
Glassy fly ash	2+			5			5			3+						6		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber																		

Table 94d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CINCINNATI AND VICINITY (COLLEGE HILL FIRE HOUSE — NO. 2)

Date	28 July 1974			8 October 1974		
TSP ($\mu g/m^3$)	140			94		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(1+)	<1-33	3	(7)		
Quartz	1-			1+	<1-40	1
Calcite	1-			4+	<1-40	2
Feldspar				1-		
Hematite				1-	<1-20	0.5
Mica						
Combustion Products	(8+)			(2+)		
Soot:						
Oil				1	<1-80	0.5
Coal	1					
Glassy fly ash	7-			1+	1-30	10
Incinerator fly ash						
Burned wood						
Burned paper						
Magnetite	1					
Biological Material	(0+)			(0+)		
Pollen						
Spores						
Paper						
Starch						
Misc. plant tissue						
Miscellaneous	(0+)			(1-)		
Iron or steel						
Rubber				1-		

Table 95. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN CINCINNATI AND VICINITY

Site	Public Library – No. 1		St. Bernard No. 12		Wyoming Elem. School – No. 8		College Hill Fire House – No. 2	
No. of filters	6		6		6		2	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(36)	24-45	(56)	28-88	(65)	25-83	(42)	15-69
Quartz	15	8-25	26	5-63	20	10-25	11	6-15
Calcite	14	5-24	24	11-38	28	10-50	24	4-45
Feldspars	6	4-10			3	2-3	3	2-4
Hematite	1	<1-2	5	1-16	14	3-45	4	3-5
Mica	Tr	0-Tr					<1	
Other	Tr	0-Tr	1	0-4				
Combustion Products	(53)	39-68	(41)	9-69	(33)	17-75	(56)	27-84
Soot:								
Oil	8	5-12			20	10-52	5	0-10
Coal	12	0-20	4	4-8	2	1-2	6	2-10
Very fine	1	0-5						
Unidentified soot			1	0-8				
Glassy fly ash	20	2-50	36	1-48	11	1-20	41	15-66
Incinerator fly ash	12	0-30			<1			
Burned wood					<1	0-1		
Burned paper					<1			
Magnetite	<1	0-1					4	0-8
Biological Material	(1)	Tr-5	(1)	<1-1	(<1)		<1	
Pollen	Tr	0-Tr	Tr	0-Tr	Tr		<1	
Spores			Tr	0-Tr	Tr		<1	
Paper	Tr	0-Tr	Tr	0-Tr	Tr		<1	
Starch	<1	0-1	<1		Tr		<1	
Misc. plant tissue	1	Tr-5	<1	0-1	Tr		<1	
Miscellaneous	(10)	Tr-20	(2)	<1-3	(2)	<1-5	(2)	<1-4
Iron or steel	<1	0-1	<1		<1		<1	
Rubber	10	Tr-20	2	0-3	2	<1-5	2	0-4

Table 96. RESULTS OF REPLICATE ANALYSES OF CINCINNATI FILTERS

Site	Public Library – No. 1					Wyoming Elem. School – No. 8		St. Bernard – No. 12			
Date	15 August 1974			26 October 1974		15 August 1974		28 July 1974		15 August 1974	
TSP ($\mu g/m^3$)	130			88		106		204		172	
Laboratory	A	A	B	A	B	A	B	A	A	A	A
Analysis	1	2	1	1	1	1	1	1	2	1	2
Component											
Minerals	(31)	(10)	(39)	(29)	(39)	(63)	(12)	(45)	(45)	(45)	(74)
Quartz	20	4		10		25		18	26	13	21
Calcite	5	3		12		25		11	15	30	45
Feldspars	4			6		3					
Hematite	2	3		1		10		16	4	2	8
Mica				Tr							
Coal				Tr							
Other											4
Combustion Products	(68)	(85)	(58)	(60)	(52)	(32)	(48)	(54)	(54)	(52)	(24)
Soot:											
Oil	8		17	12	23	20	22				
Coal	10	8		15		2		6	9	4	4
Glassy fly ash	50	77	41	15	29	10	26	48	45	48	20
Incinerator fly ash				18		<1					
Burned wood						<1					
Burned paper						<1					
Magnetite	Tr										
Biological Material	(1)	(<1)	(3)	(<1)	(9)	(<1)	(40)	(<1)	(<1)	(<1)	(<1)
Pollen		<1		Tr		<1					<1
Spores						<1		Tr		Tr	
Paper				Tr		<1			<1		
Starch	1			Tr		<1		<1	<1		
Misc. plant tissue						<1				<1	
Miscellaneous	(<1)	(4)	(<1)	(11)	(<1)	(5)	(<1)	(1)	(1)	(3)	(<1)
Iron or steel		Tr		1		<1		1	1	1	<1
Rubber	Tr	4		10		5			<1	2	

Table 97. CITYWIDE COMPOSITE
SUMMARY OF FILTERS
ANALYSES IN CINCINNATI

No. of filters	20	
	Quantity, percent	
Components	Average	Range
Minerals	(51)	24-88
Quartz	19	5-63
Calcite	22	5-50
Feldspars	3	0-10
Hematite	6	<1-45
Mica	<1	
Other	<1	
Combustion Products	(44)	9-84
Soot:		
Oil	9	0-52
Coal	6	0-20
Misc. soot	<1	
Glassy fly ash	24	1-66
Incinerator fly ash	4	0-30
Burned wood	<1	
Burned paper	<1	
Magnetite	<1	
Carbon black		
Other		
Biological Material	(1)	<1-5
Pollen	<1	
Spores	<1	
Paper	<1	
Starch	<1	0-1
Misc. plant tissue	1	0-5
Leaf trichomer		
Miscellaneous	(4)	<1-20
Iron or steel	<1	
Rubber	4	0-20
Other		

CLEVELAND

The City of Cleveland is located in Cuyahoga County in the northeastern corner of the State of Ohio and is on the southern shore of Lake Erie. Because of its location on one of the Great Lakes, Cleveland has become an important transportation, industrial, and manufacturing center. The terrain rises smoothly and gradually over 500 feet from the lake to the suburban heights of land. The Cuyahoga River cuts through the plain, bisecting the city and forming a rather deep and narrow north-south valley.

Cleveland is highly industrialized — the industries are mainly concerned with primary metals, metal fabrication, machinery, tools, and automotive parts but also include numerous other products.

The climate is moderately cold, averaging 6150 heating degree-days per year with moderate rainfall, an average of 35 inches per year. The presence of Lake Erie strongly influences Cleveland's climate and produces a lake breeze during the summer. Inversions occur frequently in the river valley. A more detailed discussion of the city is presented in Volume XII.

Twelve of the 25 sites in the county exceeded the annual primary standard of 75 $\mu g/m^3$ and nine others exceeded the annual secondary standard, 60 $\mu g/m^3$. The 24-hour primary standard was exceeded on 73 sampling days (4.7 percent) and the secondary standard on 273 sampling days (17.6 percent). Citywide air quality monitoring began in 1967 and since 1970, 15 sites in the city have had an average decrease of 36.5 $\mu g/m^3$ in annual mean TSP concentrations.

The locations of the five sites that were selected for filter analysis in Cleveland are shown in Figure 19. Table 98 details the pertinent characteristics of these sites, and Table 99 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 100. The results for each of the 21 filters submitted for routine analysis are presented in Table 101. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 102. Six filters underwent replicate analyses, and the results are presented in Table 103.

The composite particulate characterization for all filters from Cleveland that underwent routine analysis, presented in Table 104, shows that minerals predominate but that the contribution of combustion products is also high. Indeed only one other study city was found to have higher average percent combustion products and only two cities displayed as low or lower levels of minerals. The combustion products category is comprised primarily of glassy fly ash and coal soot which reflects the substantial utilization of coal by industry and utilities.

The Supplementary Education Center in the downtown area showed considerably higher levels of minerals than the other sites. This is most likely the result of local fugitive emissions from the nearby parking lots and urban renewal areas. Rubber was also detected on most filters although its average citywide contribution amounted to less than 10 percent and only eighth highest in that category of the 14 study cities. The J. F. Kennedy High School had the highest average percent rubber although the TSP levels are generally low at that site.

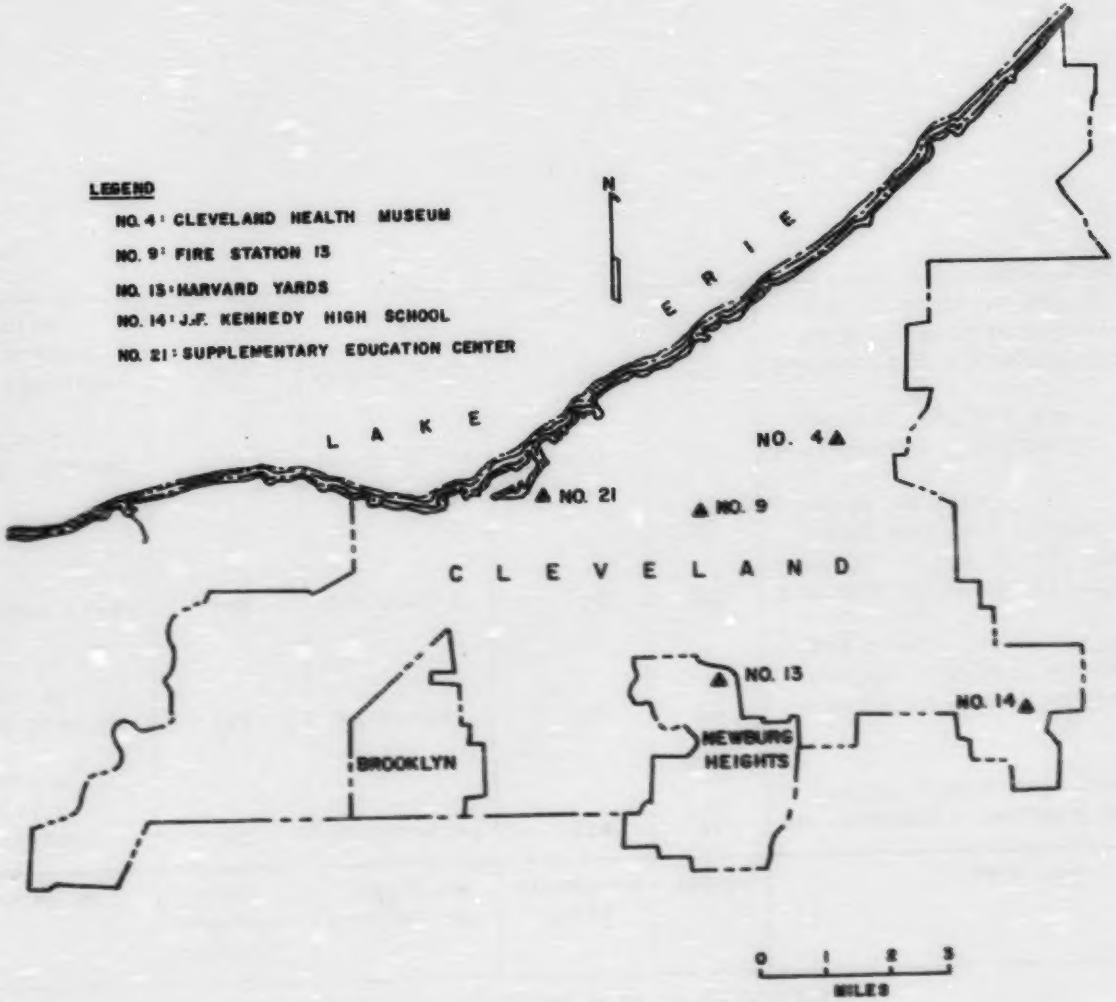

LEGEND
NO. 4: CLEVELAND HEALTH MUSEUM
NO. 9: FIRE STATION 13
NO. 13: HARVARD YARDS
NO. 14: J.F. KENNEDY HIGH SCHOOL
NO. 21: SUPPLEMENTARY EDUCATION CENTER
N
LAKE ERIE
NO. 4
NO. 21
NO. 9
CLEVELAND
NO. 13
NO. 14
BROOKLYN
NEWBURG HEIGHTS
0
1
2
3
MILES

Figure 19. Location of monitoring sites selected for filter analysis in Clevland

Table 98. SAMPLING SITE DESCRIPTIONS

Site number	Location	1974 TSP geometric mean	Predominant influence	Total elevation	Height	Land use
4	Cleveland Health Museum	90	Residential	699	24	Surrounding – residential; heavy traffic; hospitals nearby
9	Fire Station No. 13	147	Industrial	703	23	Surrounding – residential; heavy traffic; industrial valley – 1/4 mile W (steel mills)
13	Harvard Yards	168	Industrial	700	60	Surrounding – industrial (steel mills, stock piles, unpaved roads and lots, truck traffic, railroad yard)
14	J. F. Kennedy School	50	Residential	1,070	60	Surrounding – residential; supermarket, parking lot
21	Supplementary Education Center	112	Center city	705	65	Surrounding – commercial; Lake Erie – 3/4 mile NW; heavy traffic; industrial valley – 1 mile S

Table 99. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (CLEVELAND HOPKINS INTERNATIONAL AIRPORT)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
3/18/74	0.08	t	13.8	10.4	290, 300, 260, 260 240, 200, 200, 190	240
4/17/74	0	0	7.3	5.8	220, 220, 210, 240 300, 300, 230, 210	250
4/29/74	t	t	11.7	9.3	190, 220, 210, 220 290, 270, 310, C	240
6/04/74	0	0.05	7.6	7.0	180, 220, 190, 210 240, 220, 180, 170	200
6/28/74	0.32	0	7.1	5.2	60, 110, 140, 90 30, 60, 80, 170	80
7/31/74	0	t	7.5	5.7	250, 220, 230, 230 280, 290, 320, 180	250

Note: C = Calm
t = Trace

Table 100. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE CLEVELAND, OHIO, NASN SITE NO. 361300001 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	16.62[a]	15.34[a]	3.63[a]	3.05[a]
1973	12.46[a]	11.66[a]	4.05[a]	3.03[a]
1974	10.50[a]	9.97[a]	1.34[a]	1.02[a]

[a] Indicates insufficient data for statistically valid year.

Table 101a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CLEVELAND AND VICINITY (SUPPLEMENTARY EDUCATION CENTER — NO. 21)

Date	18 March 1974			17 April 1974			29 April 1974			4 June 1974			28 June 1974			31 July 1974		
TSP ($\mu g/m^3$)	71			264			172			472			160			121		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(8)	2-90	10	(8)	1-60	12	(5)	<1-50	12	(6)	<1-50	15	(4)	<1-62	12	(7+)	<1-60	10
Quartz	3+			1+			2			1			1			3		
Calcite	2+			3			2			2			1			4		
Feldspars	1			1-														
Hematite	1			3			1			3			2			1-		
Mica	1-																	
Combustion Products	(1+)	<1-60	15	(2-)	<1-48	1	(4)	<1-45	9	(4-)	<1-150	30	(6)	<1-60	15	(2)	<1-48	6
Soot:																		
Oil																		
Coal				1+			1			1			1-			1-		
Coked coal soot	1-																	
Glassy fly ash	1-			1-			3			2+			5+			1		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																1-		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1-)	10-45	31	(0+)			(1)	8-130	30	(1-)	2-30	18	(0+)			(1-)		
Iron or steel										1-								
Rubber	1-						1									1-		

Table 101b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CLEVELAND AND VICINITY (HARVARD YARDS — NO. 13)

Date	18 March 1974			17 April 1974			29 April 1974			31 July 1974		
TSP (µg/m^3)	150			327			238			244		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(5)			(4)			(4)			(7)	<1-45	10
Quartz	2	5-90	30	1+	5-80	30	2	10-50	25	3		
Calcite	1+	1-125	25	1	2-60	20	1	5-50	20	3		
Feldspars	1-	1-100	25	1	2-50	20	1-	5-50	20			
Hematite	1	1-50	10	1	1-50	20				1		
Mica												
Combustion Products	(3)			(5+)			(5+)			(3-)	<1-80	1
Soot:												
Oil	1	1-40	25	1	20-100	30	1+	10-200	100			
Coal				1+	5-80	30	2+	2-70	30	1-		
Glassy fly ash	1	5-100	35	1-	5-40	25	1+	4-40	20	2		
Incinerator fly ash	1-	1-75	40	1	5-100	30						
Burned wood												
Burned paper												
Magnetite				1+	5-50	25						
Biological Material	(0+)			(0+)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(2)			(1)			(1-)			(1-)		
Iron or steel	2	5-75	40									
Rubber				1	20-150	70	1-	10-50	25			

Table 101c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CLEVELAND AND VICINITY (FIRE STATION NO. 13 — NO. 9)

Date	18 March 1974			29 April 1974			4 June 1974			28 June 1974			31 July 1974		
TSP ($\mu g/m^3$)	243			339			141			134			163		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity. tenths	Size range, μm	Avg. size, μm
Minerals	(6)	<1-30	8	(8+)	<1-20	6	(3)			(3)			(3)		
Quartz	2			1			1-	5-60	20	1-	2-35	25	1+	10-75	30
Calcite	2			2+			1+	2-75	25	1+	1-15	8	1-	2-45	20
Feldspars							1-	2-50	15	1-	1-20	10	1-	5-100	25
Hematite	2			5			1-	1-100	15	1-	<1-15	5			
Mica															
Combustion Products	(4)	<1-180	9	(1)	<1-45	5	(5+)			(7)			(5)		
Soot:															
Oil	1						1	5-100	35	3			2-	10-100	30
Coal	2-			1-			2-	5-100	25	1+			2	5-75	30
Glassy fly ash	1			1-			1+	4-60	20	2+			1-	5-60	30
Incinerator fly ash							1-	1-70	20						
Burned wood															
Burned paper															
Magnetite							1-	5-50	20				1-	1-40	15
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(0+)			(1-)			(2-)			(0+)			(2)		
Iron or steel													1-	5-20	10
Rubber							2-	20-100	40				1+	20-100	40

Table 101d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN CLEVELAND AND VICINITY (J. F. KENNEDY HIGH SCHOOL — NO. 14 AND CLEVELAND HEALTH MUSEUM — NO. 4)

Site	J. F. Kennedy High School – No. 14									Cleveland Health Museum – No. 4								
Date	18 March 1974			17 April 1974			29 April 1974			4 June 1974			28 June 1974			31 July 1974		
TSP (μg/m³)	42			93			86			162			117			102		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size μm
Minerals	(4+)			(3)			(4+)			(3+)			(3+)			(6-)		
Quartz	2+	5-75	30	1	2-50	30	2	5-100	25	2	5-70	30	1+	5-35	15	2	5-120	35
Calcite	1	5-75	30	1	1-30	20	1	1-75	25	1-	1-30	10	1	1-40	20	2	2-60	30
Feldspars				1-	2-50	20	1	1-70	20				1-	5-60	25	1	2-75	25
Hematite	1-	1-25	10				1-	1-75	10				1-	1-30	10	1	1-75	15
Mica																		
Other										1-	5-50	20						
Combustion Products	(3+)			(5+)			(3+)			(6+)			(4+)					
Soot:																		
Oil	9	5-75	30	2+	5-100	30	1	10-100	25	2	2-50	20	1	10-100	40	1	10-70	25
Coal	8	5-80	30	2	5-60	30	1+	5-150	35	1+			1+	5-100	30	2	1-100	35
Glassy fly ash	1+	2-50	15	1+	2-25	10	1	5-60	30	2+	2-40	15	1-	5-40	20	1-	5-50	20
Incinerator fly ash	1-	1-50	20				1	5-100	30				1	1-150	30			
Burned wood																		
Burned paper																		
Magnetite										1-						1-	5-25	15
Biological Material	(0+)			(0+)			(1-)			(0+)			(1-)			(0+)		
Pollen							1-	20-50	30									
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(2)			(1)			(1+)			(0+)			(1+)			(1-)		
Iron or steel																		
Rubber	2			1	20-200	50	1+	20-100	50				1+	20-100	35	1-	20-120	50

Table 102. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN CLEVELAND AND VICINITY

Site	Supplementary Education Center — No. 21		Harvard Yards No. 13		Fire Station No. 13 — No. 9		Cleveland Health Museum No. 4		J.F. Kennedy High School No. 14	
No. of filters	6		4		5		3		3	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(65)	40-82	(50)	38-70	(47)	28-85	(42)	35-56	(41)	32-45
Quartz	21	10-35	22	15-31	11	5-20	18	15-20	19	12-25
Calcite	24	9-40	16	8-29	16	6-26	12	7-18	12	10-12
Feldspars	2	0-9	5	0-8	3	0-5	5	2-8	6	2-10
Hematite	17	4-30	7	2-10	17	2-50	6	2-10	4	2-6
Mica	<1	0-1			tr	0-tr			<1	0-1
Other	1	0-1			tr	0-tr	1	0-4		
Combustion Products	(31)	13-60	(40)	26-54	(44)	10-70	(49)	37-65	(43)	35-55
Soot:										
Oil			9	0-15	14	0-30	13	8-20	12	8-20
Coal	8	0-13	11	0-25	14	4-20	16	15-19	14	8-20
V.F. soot					tr	0-tr				
Coked coal soot	1	0-6								
Glassy fly ash	21	4-55	12	5-21	13	5-25	13	5-25	11	5-15
Incinerator fly ash			4	0-10	1	0-4	3	0-8	5	0-10
Burned wood										
Burned paper										
Magnetite	1	0-5	4	0-15	2	0-6	4	2-5	1	0-2
Biological Material	(<1)		(1)		(<1)		(2)		(2)	
Pollen	tr	0-tr	1	0-2	tr	0-tr	<1	0-1		tr-5
Spores	tr	0-tr	tr	0-tr	tr	0-tr			tr	0-tr
Paper	tr	0-tr	tr	0-tr	tr	0-tr	<1	0-1	tr	0-tr
Starch	tr	0-tr	tr	0-tr	tr	0-tr	<1	0-1	tr	0-tr
Misc. plant tissue	tr	0-tr	tr	0-tr	tr	0-tr	<1	0-1	tr	0-tr
Miscellaneous	(4)	tr-10	(9)	4-22	(9)	(tr-22)	(7)		(14)	10-20
Iron or steel	1	<1-5	5	0-20	2	0-5	<1			
Rubber	3	0-9	4	2-9	6	0-16	7	tr-15	14	12-20
Graphite					1	0-2	<1	0-1		

Table 103. RESULTS OF REPLICATE ANALYSES OF CLEVELAND FILTERS

Site	Fire Station No. 13 – No. 9		Harvard Yards – No. 13					Supplementary Education Center – No. 21					
Date	4 June 1974		18 March 1974			31 July 1974		29 Apr.1974		4 June 1974		28 June 1974	
TSP ($\mu g/m^3$)	141		150			244		172		472		160	
Laboratory	A	B	A	A	B	A	A	A	B	A	B	A	A
Analysis	1	1	1	2	1	1	2	1	1	1	1	1	2
Components													
Minerals	(31)	(31)	(50)	(63)	(45)	(70)	(63)	(50)	(39)	(59)	(64)	(40)	(42)
Quartz	6		20	25		31	27	19		12		10	11
Calcite	14		15	25		29	28	20		18		9	9
Feldspars	5		5										
Hematite	6		10	15		10	7	10		29		20	21
Mica								1					
Other							1					1	1
Combustion Products	(53)	(66)	(28)	(27)	(54)	(26)	(32)	(40)	(60)	(36)	(35)	(60)	(57)
Soot:													
Oil	12	14	12		11				5		6		
Coal	15			1		5	8	9		12		5	5
Glassy fly ash	16	52	10	18	43	21	24	31	55	24	29	55	50
Incinerator fly ash	4		6										
Burned wood													
Burned paper													
Magnetite	6			8			1						2
Biological Material	(<1)	(3)	(<1)	(<1)	(1)	(<1)	(1)	(<1)	(1)	(<1)	(1)	(<1)	(<1)
Pollen	tr					<1	<1	<1					
Spores							<1						
Paper	tr		tr									tr	
Starch	tr							tr					
Misc. plant tissue	tr			<1			1						
Leaf trichomer								<1		tr		<1	<1
Miscellaneous	(16)	(<1)	(22)	(10)	(<1)	(4)	(4)	(10)	(<1)	(5)	(<1)	(<1)	(1)
Iron or steel			20	8		<1	4	1		5		tr	1
Rubber	16		2	2		3		9					<1

Table 104. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN CLEVELAND

No. of filters	21	
	Quantity, percent	
Components	Average	Range
Minerals	(51)	28-85
Quartz	18	5-35
Calcite	17	6-40
Feldspars	4	0-10
Hematite	12	2-50
Mica	<1	
Other	<1	
Combustion Products	(40)	10-70
Soot:		
Oil	9	0-30
Coal	12	0-25
Misc. soot	<1	
Glassy fly ash	15	4-55
Incinerator fly ash	2	0-10
Burned wood		
Burned paper		
Magnetite	2	0-15
Carbon black		
Other		
Biological Material	(1)	<1-5
Pollen	1	0-5
Spores	<1	
Paper	<1	
Starch	<1	
Misc. plant tissue	<1	
Leaf trichomer		
Miscellaneous	(8)	tr-22
Iron or steel	2	0-20
Rubber	6	0-20
Other	<1	

SAN FRANCISCO

The San Francisco Bay Area AQCR is located on the Pacific coast of northern California. The center of the AQCR is the San Francisco Bay, a large shallow basin ringed by hills as high as 2000 feet and tapering into a series of sheltered valleys. This topography gives the area great potential for trapping and accumulating air pollutants. The area is lightly industrialized with many of the major point sources located away from the centers of population, so that overall there is a rather low emission density. The climate is moderately warm, averaging 3044 heating degree-days per year, with somewhat light amounts of precipitation, an average of 19.5 inches per year. The seasonal patterns of ventilation and precipitation seem to affect TSP levels. TSP levels are greatest (up to 50 percent higher) during the summer and autumn months when ventilation is reduced and precipitation is lightest. A more detailed discussion of the city is presented in Volume XIII.

None of the 17 monitors in the AQCR exceeded the annual primary standard in 1974 while only two exceeded the annual secondary standard. None of the sites exceeded the 24-hour primary standard more than once and only 24 of the more than 1800 observations in 1974 exceeded the 24-hour secondary standard.

The locations of the three sites that were selected for filter analysis in San Francisco are shown in Figure 20. Table 105 details the pertinent characteristics of these sites, and Table 106 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 107. The results for each of the 14 filters submitted for routine analysis are presented in Table 108. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 109. Four filters underwent replicate analyses, and the results are presented in Table 110.

The composite particulate characterization for all filters from San Francisco that underwent routine analysis, presented in Table 111, shows that minerals make up a majority of the particulate but do not predominate to the degree as in most other study cities. San Francisco ranked fourth lowest in that category. Of the three sites from which filters were analyzed, Livermore had the highest percent minerals. This site also experienced the highest TSP levels in 1974 and is exposed to nearby dirt parking lots, gravel pits and highway construction.

The most striking result of the filter analyses is the large amount of rubber observed. San Francisco ranked highest of all study cities with a citywide average of 16 percent. The station at 939 Ellis Street consistently had the highest percentage of rubber but the lower overall TSP levels at that site probably inflate a fairly uniform rubber concentration into a higher percentage. If the microscopy results can be used as a reliable distribution of the entire particulate mass, then the average rubber concentration at this site would be just over 13 $\mu g/m^3$. Likewise at both the Livermore and East San Francisco sites, the concentrations would be about 9 $\mu g/m^3$. This seems to imply a citywide phenomenon rather than localized observations as has been observed in some cities.

The Bay Area Air Pollution Control District performs extensive chemical analyses on the material collected on hi-vol filters. The analyses are not performed on the regular glass fiber filters that are run every sixth day, but on Whatman 41 filter papers which are also run every sixth day but three days displaced from the glass fiber filter schedule. The resulting data, although not directly comparable to the sampling days reported herein, give a very good picture of the concentrations of some chemical constituents of environmental concern. Table 112 gives the annual geometric mean concentrations of eight constituents for the three sites from which filters were selected for microscopic analysis. It can be seen that the two sites closer to the salt water (SF9 and SF10) have much higher concentrations of chloride than the Livermore site, as would be expected. SF9 also reports higher levels of lead which is probably the result of the nearby parking garage as well as higher traffic levels.

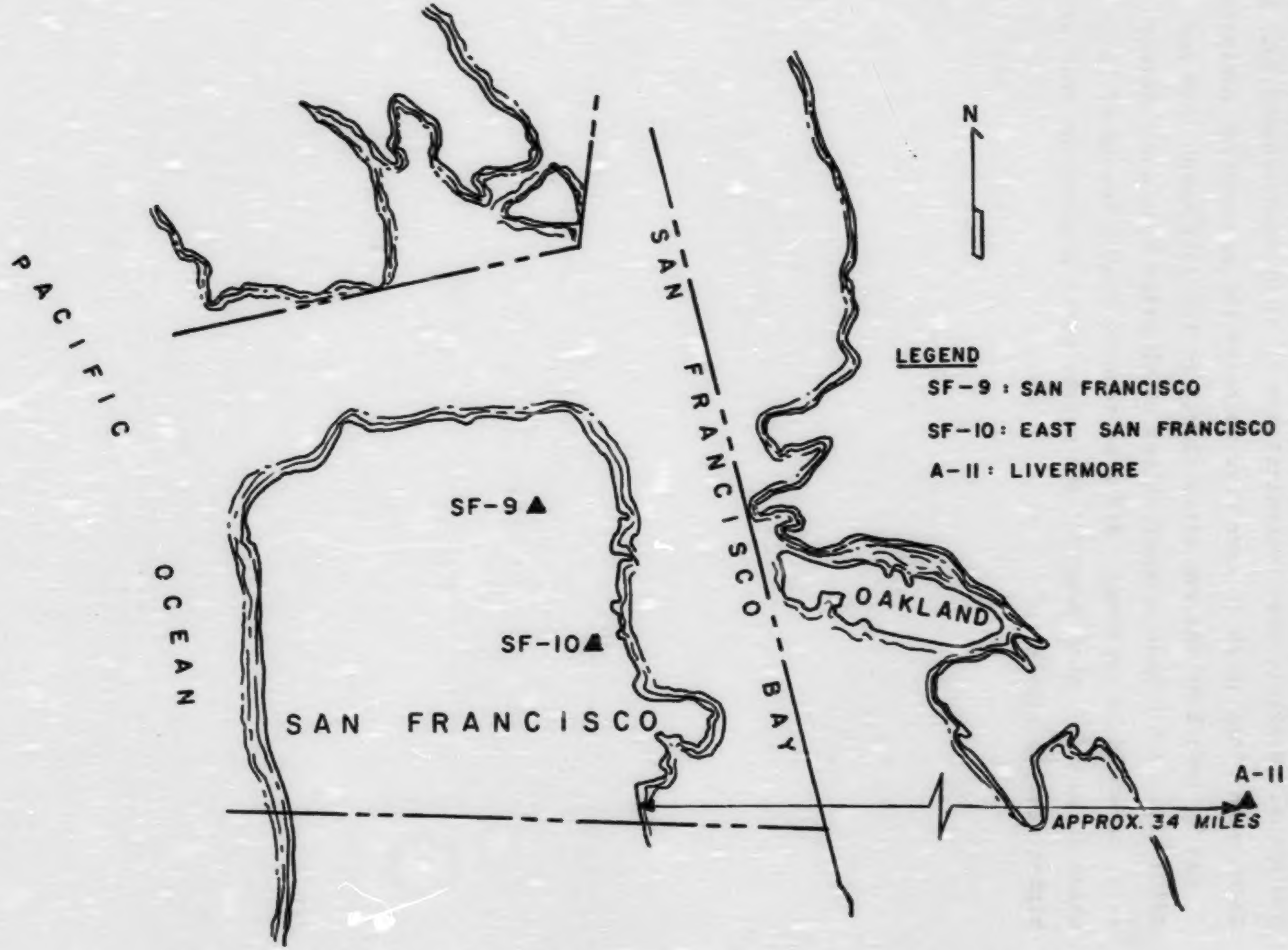

N
LEGEND
SF-9 : SAN FRANCISCO
SF-10 : EAST SAN FRANCISCO
A-11 : LIVERMORE
PACIFIC OCEAN
SAN FRANCISCO BAY
SF-9
SF-10
SAN FRANCISCO
OAKLAND
A-11
APPROX. 34 MILES

Figure 20. Location of monitoring sites selected for filter analysis in San Francisco

Table 105. CHARACTERISTICS OF BAAPCD MONITOR SITES REVIEWED

Neighborhood	Map code	Location	1974 Annual geometric mean, $\mu g/m^3$	Height above ground, ft	Siting comments
Industrial	SF10	East San Francisco	NA	30	Trucking terminals, and light to moderate industry area, good exposure.
Commercial	SF9	San Francisco	53	15	Poor exposure, building directly to west of monitor, monitor surrounded on all four siees to height of 3 feet, window box with dirt at intake level 3 feet to east, gas station stack 50 feet to ENE.
	All	Livermore	74	18	Good exposure to large amounts of fugitive dust - dirt parking lots, gravel pits, highway construction, etc., no major industry noticeable.

Table 106. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (SAN FRANCISCO INTERNATIONAL AIRPORT)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
2/10/74	0	0	8.8	–	310, 300, 300, 280 250, 190, 210, 210	–
4/5/74	0	0.01	11.2	–	200, 270, 270, 290 290, 300, 20, 310	–
4/29/74	0	0	14.4	–	280, 280, 330, 300 300, 310, 310, 300	–
6/10/74	0	0	13.4	–	310, 300, 310, 300 300, 320, 340, 330	–
7/22/74	0	0	13.9	–	300, 310, 310, 310 310, 310, 310, 310	–
8/21/74	0	0	12.2	–	310, 310, 310, 300 300, 300, 50, 310	–

Note: C = Calm

Sampling time, 1500 to 1500; sampling date recorded as start day.

Average wind speed is average of 3-hour observations.

Table 107. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE SAN FRANCISCO, CALIFORNIA NASN SITE NO. 056860001 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	5.58	5.14	2.75	2.00
1973	5.16	4.85	3.52	2.13
1974	5.13	4.90	3.51	2.70

Table 108a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN SAN FRANCISCO AND VICINITY (LIVERMORE — NO. A-11)

Date	10 February 1974			5 April 1974			29 April 1974			10 June 1974			22 July 1974			21 August 1974		
TSP ($\mu g/m^3$)	94			48			100			121			100			104		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(7)			(7+)			(5)			(4)			(7)			(6)		
Quartz	3+	5-40	25	5	5-35	25	2+	5-50	35	2	2-25	12	3	5-30	20	2+	5-25	15
Calcite				1	5-25	15	1-	5-35	25	1-	2-10	5	1	2-15	7			
Feldspars	3	5-50	20	1	10-50	20	2	2-40	20	1+	2-40	15	3	2-40	20	3+	1-50	20
Hematite																		
Mica																		
Combustion Products	(2)			(2)			(4)			(4-)			(2)			(3)		
Soot:																		
Oil										1-	15-40	25	1-	10-30	20			
Coal	1	5-75	30	2	5-75	50	2+	5-50	30				1-	10-60	40	1	5-60	25
Glassy fly ash																		
Incinerator fly ash	1-	5-50	30				1+	10-75	40	3	2-40	10	1	5-100	40	2	10-100	60
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(1-)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1)			(1-)			(1)			(2)			(1-)			(1-)		
Iron or steel																		
Rubber	1	10-150	100	1-	25-125	75	1	20-200	75	2	10-50	20	1-			1-		

Table 108b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN SAN FRANCISCO AND VICINITY (SAN FRANCISCO — NO. SF-9)

Date	10 February 1974			5 April 1974			29 April 1974			10 June 1974			22 July 1974			21 August 1974		
TSP ($\mu g/m^3$)	44			38			65			88			54			50		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(3)			(6-)			(4+)			(3)			(5)			(5)		
Quartz	1+	5-60	25	2	5-70	15	3+	5-70	30	1+	5-25	15	2+	3-25	10	2	10-70	40
Calcite				1+	5-40	15	1-	2-20	5	1	4-20	10	1-	2-20	10	1-	5-30	15
Feldspars	1	2-40	15	2	2-50	20	1-	2-30	10	1-	4-50	20	2	1-40	15	2+	5-50	25
Hematite																		
Mica																		
Combustion Products	(5-)			(1)			(2)			(5)			(1)			(3-)		
Soot:																		
Oil	1	2-60	20				1-	10-40	25	1-	10-30	20				1-	15-25	20
Coal	2	5-100	25										1	5-60	30	1+	5-55	35
Glassy fly ash	1	2-15	8															
Incinerator fly ash	1	5-50	20	1	10-100		2-	2-60	20	4+	2-60	30				1-	5-75	40
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(1)			(1)			(1-)			(1-)			(0+)		
Pollen				1-	15-35	20	1-	20-50	30									
Spores																		
Paper				1-	50-600	400												
Starch																		
Misc. plant tissue							1-											
Miscellaneous	(2+)			(3-)			(2+)			(2-)			(3+)			(2)		
Iron or steel	2+	20-120	60															
Rubber				3-	50-200	75	2+	20-120	30	2-	20-200	100	2+			2	10-200	
Salt													1	4-10	6			

Table 108c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN SAN FRANCISCO AND VICINITY (EAST SAN FRANCISCO - NO. SF-10)

Date	22 July 1974			21 August 1974		
TSP ($\mu g/m^3$)	75			102		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(6)			(4)		
Quartz	2	5-35	20	2	5-30	20
Calcite	2-	5-20	10	1-	2-20	10
Feldspars	2	2-60	30	1+	2-40	20
Hematite	1	2-10	4			
Mica						
Combustion Products	(3)			(4)		
Soot:						
Oil						
Coal						
Glassy fly ash						
Incinerator fly ash	2	10-80	40	3+	1-60	20
Burned wood	1	30-80	30			
Burned paper						
Magnetite						
Biological Material	(1-)			(0+)		
Pollen						
Spores						
Paper						
Starch						
Misc. plant tissue						
Miscellaneous	(0+)			(2)		
Iron or steel						
Rubber				(2)	20-150	70

Table 109. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN SAN FRANCISCO AND VICINITY

Site	San Francisco No. SF-9		Livermore No. A-11		East San Francisco No. SF-10	
No. of filters	6		6		2	
	Quantity, percent		Quantity, percent		Quantity percent	
Components	Average	Range	Average	Range	Average	Range
Minerals	(43)	29-56	(61)	40-73	(51)	39-62
Quartz	22	15-35	31	20-50	19	18-19
Calcite	6	2-15	6	2-12	10	4-16
Feldspars	14	6-25	23	10-35	17	15-18
Hematite	1	tr-1	1	0-1	5	2-8
Mica			tr	0-tr	tr	0-tr
Combustion Products	(28)	10-50	(27)	18-39	(36)	33-41
Soot:						
Oil	4	0-8	2	0-6	1	0-2
Coal	8	0-18	12	0-25	2	0-3
Fine soot	<1	0-2				
V.V. fine					1	0-2
Glassy fly ash	2	0-10	<1	0-1		
Incinerator fly ash	14	0-45	13	0-30	25	18-35
Burned wood					6	2-10
Burned paper						
Magnetite					1	0-2
Biological Material	(5)	tr-10	(2)	tr-5	(3)	tr-5
Pollen	2	tr-5	2	tr-3	1	tr-1
Spores	tr	0-tr	tr	0-tr	tr	0-tr
Paper	1	0-1	<1	0-1	tr	0-tr
Starch	tr	0-tr	<1	0-1	<1	0-tr
Misc. plant tissue	2	tr-5	<1	0-1	2	tr-3
Miscellaneous	(24)	16-35	(10)	5-21	(10)	0-20
Iron or steel						
Rubber	22	16-26	10	5-21	10	0-20
Salt	2	0-10				

Table 110. RESULTS OF REPLICATE ANALYSES OF SAN FRANCISCO FILTERS

Site	San Francisco — No. SF-9					East San Francisco No. SF-10				Livermore No. A-11	
Date	10 June 1974			21 August 1974		21 August 1974				10 June 1974	
TSP (μg/m³)	88			50		102				121	
Laboratory	A	A	B	A	B	A	A	B	B	A	A
Analysis	1	2	1	1	1	1	2	1	2	1	2
Components											
Minerals	(30)	(63)	(39)	(50)	(52)	(39)	(75)	(31)	(32)	(40)	(91)
Quartz	15	25		20		18	30			20	35
Calcite	8	30		5		4	30			4	50
Feldspars	6	3		25		15	4			15	2
Hematite	1	5		tr		2	7			1	4
Mica						tr	<1			tr	<1
Gypsum							4				
Combustion Products	(50)	(28)	(61)	(27)	(48)	(41)	(5)	(69)	(68)	(36)	(5)
Soot:											
Oil	5	25	8	5	4	2	5	12	5	6	5
Coal		1		15			<1				<1
V.v.fine						2					
Glassy fly ash		2	53		44		<1	57	63		<1
Incinerator fly ash	45			7		35	<1			30	
Burned wood						2					
Burned paper											
Magnetite											
Biological Material	(4)	(5)	(<1)	(3)	(<1)	(<1)	(<1)	(<1)	(<1)	([illegible])	(<1)
Pollen	1			tr		tr	<1			3	
Spores		<1					<1				<1
Paper	1	<1		2		tr	<1			tr	
Starch		<1		tr						tr	
Misc. plant tissue	2	5		1		tr	<1			tr	
Miscellaneous	(16)	(4)	(<1)	(20)	(<1)	(20)	(20)	(<1)	(<1)	(21)	(4)
Iron or steel		<1					<1				<1
Rubber	16	4		20		20	20			21	4

Table 111. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN SAN FRANCISCO

No. of filters	14	
	Quantity, percent	
Components	Average	Range
Minerals	(52)	29-73
Quartz	25	15-50
Calcite	7	2-16
Feldspars	18	6-35
Hematite	2	0-8
Mica	<1	
Other		
Combustion Products	(29)	10-50
Soot:		
Oil	3	0-8
Coal	9	0-25
Misc. soot	<1	0-2
Glassy fly ash	1	0-10
Incinerator fly ash	15	0-45
Burned wood	1	0-10
Burned paper		
Magnetite	<1	0-2
Carbon black		
Other		
Biological Material	(3)	tr-10
Pollen	2	tr-5
Spores	<1	
Paper	<1	
Starch	<1	
Misc. plant tissue	1	0-5
Leaf trichomer		
Miscellaneous	(16)	0-35
Iron or steel		
Rubber	16	0-26
Other	<1	0-10

Table 112. 1974 GEOMETRIC MEAN CONCENTRATIONS OF SELECTED PARTICULATE CONSTITUENTS AT THREE BAAPCD SITES

Constituent	Site					
	All		SF9		SF10[a]	
	No. of observations	Concentration, $\mu g/m^3$	No. of observations	Concentration, $\mu g/m^3$	No. of observations	Concentration, $\mu g/m^3$
Cu	30	0.125	29	0.096	11	0.120
Pb	30	0.415	29	0.939	11	0.498
Mn	29	0.036	18	0.014	11	0.025
Zn	30	0.080	28	0.064	12	0.111
NH_4^+	27	0.876	26	0.662	7	1.150
$SO_4^=$	25	1.529	26	3.348	9	4.096
NO_3^-	27	3.384	26	2.839	9	3.126
Cl^-	27	0.795	26	3.305	9	2.692

[a] Observations from July - December only.

MIAMI

The Southeast Florida Intrastate AQCR consists of the eight counties located along the southern and eastern coasts of Flordia. The AQCR extends from the Keys to Indian River on flat, often marshy land. Much of the nonurban area outside metropolitan Miami is part of the Everglades swamp. The Miami area is a lightly-industrialized resort and retirement community. Major employment groups are the wholesale and retail trades, professional services, and manufacturing.

The climate in Miami is marine subtropical influenced by the Gulf Stream. The average annual temperature is 75°F, with little seasonal variation. Rainfall is moderate to heavy, averaging about 60 inches, and winds are moderate with seasonal directions: northerly in the winter and east to southeast during the remainder of the year. Wind speeds and mixing heights are such as to normally prevent the occurrence of inversions over the city. The reader is directed to Volume XIV of this report for a complete discussion of the subject city.

The 1974 geometric mean TSP concentrations in Dade County ranged from 42 $\mu g/m^3$ to 86 $\mu g/m^3$. In general, patterns of TSP levels do not obviously relate to conventional land-use categories (residential, commercial) but rather reflect more local conditions. The citywide mean TSP concentration for 1974 was 61 $\mu g/m^3$, nearly meeting the national secondary standard (60 $\mu g/m^3$). Seven of the 17 sites had annual means above that standard, and two did not meet the primary standard of 75 $\mu g/m^3$. The 24-hour primary standard — 260 $\mu g/m^3$ — was not exceeded in 1974, while the secondary standard of 150 $\mu g/m^3$ was exceeded at three of the stations; the greatest frequency of violations was 10 percent of the observations at the same site that had the second highest 1974 mean TSP level — 79 $\mu g/m^3$.

Sampling in the Miami area began in 1965 with eight stations, and by 1974 there were 17 sites sampling at least part of the year. TSP levels have fluctuated over time with peak years being 1971 and 1973 at most sites. 1974 levels were somewhat higher than 1967, averaging about 10 $\mu g/m^3$ higher over the entire city.

Historical data concerning the composition of the suspended particulate matter in Miami is quite limited, with the NASN site having the most information. The NASN site, Number 1 in Figure 21, is located about 30 feet above grade and had a 1974 geometric mean TSP level of 75 $\mu g/m^3$. Table 113 shows the sulfate and nitrate levels at this site to be low compared to the industrialized areas of the country; the total annual average contribution of these two components is only 7 to 8 micrograms per cubic meter.

Samples from three filters at the NASN site were obtained for microscopic examination. The meteorological data for the three sampling days are summarized in Table 114, and the results of the analysis of the three filters are presented in Table 115. The results of the three analyses have also been averaged to provide a composite summary as shown in Table 116.

It is apparent that minerals predominate in the collected particulate material; Miami ranks behind only Oklahoma City and Denver with respect to the average percent minerals. The suspended particulate concentrations are lower in Miami than in many cities, however, so the actual concentration of the constituents must be scaled accordingly. Although only a limited number of samples from the one site were analyzed, these results showed Miami to have the fourth highest average rubber content and to be one of only two sutdy cities that was shown to have more rubber than combustion products. This implicates vehicular reentrainment as being at least partially responsible for the observed mineral content.

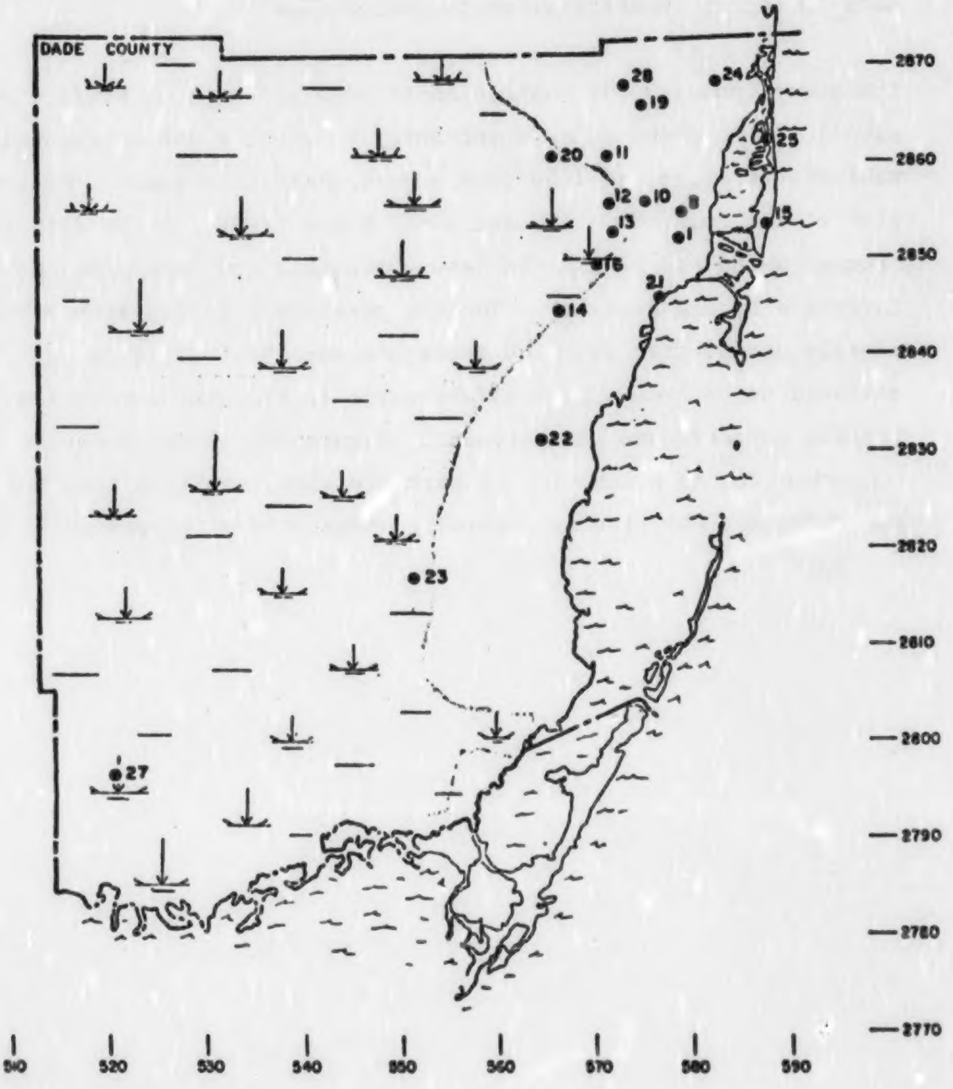
During June 1975 the Aerosol Research Branch of EPA conducted a special ambient air sampling program in Miami. This study included both conventional and novel sampling and analysis procedures and involved sampling at Dade County sites no. 10, 11, and 14. Daily TSP levels were monitored with conventional hi-vols while special instrumentation allowed determination of elemental composition over short time intervals, the size distribution of particulates as a function of wind direction, and the corresponding elemental composition of the size fractionated samples.

A novel sampling device, known as the streaker,[1] allowed collection of particulate material fo subsequent determination of 18 metals with a 2-hour time resolution. This device draws an air sample at a rate of 2 liters per minute through a strip of Nuclepore filter. The sampling head moves at a rate of 2 millimeters per hour which allows the collection of particulate matter for several days of unattended operation. The filter strip is then removed for elemental determination of the particulate by proton-induced X-ray emission analysis.[2] This technique is useful for determining the following elements: aluminum, silicon, phosphorus, sulfur, carbon, potassium, calcium, titanium, vanadium, chromium, manganese, iron, nickel, copper, zinc, bromine, strontium, and lead. The use of this powerful analytical technique, combined with the short time resolution of the sampling device, facilitates correlation of the chemical properties of particulate with meteorological parameters.

The ARB studies also included cascade impactors that were controlled by a wind direction sensor. Up to four impactors were operated such that each was operating only when the wind was from a desired direction. For example, each of four impactors could be run only when the wind was from a particular 90 degree sector so that the particle size distribution as a function of the four selected wind directions could be determined. The impactors utilized were low flow rate instruments so that long sampling times (e.g., 1 week) were required. The particulate collected on the impactor stages was also subjected to proton-induced X-ray emission analysis, indicating the elemental composition as a function of particle size.

The results of the study are far too comprehensive for presentation here and will be published separately by EPA. However, examination of the resulting data in the light of issues posed by the study visit provided some confirmations and emphasized the usefulness of such special monitoring data in source identification investigations.

The study included the collection of detailed data on traffic volumes at site 10; this provided an opportunity to examine the relationship between vehicular traffic and lead levels on a short time scale. Figure 22 is a plot of the combined north and south bound traffic on NW 27th Avenue between NW 66 and 67 and the lead concentrations determined at 2-hour intervals by the streaker. The two parameters follow each other very closely except that the lead peaks precede the traffic peaks. This is believed to be caused by a slight error in the synchronization of the traffic counters and the streaker. Figure 23, which shows the lead concentration as a function of particle size, confirms the common presumption that the lead is generally associated with very small particles.


DADE COUNTY
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570
580
590

Figure 21. Locations of air quality monitoring sites in Dade County

Table 113. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE MIAMI, FLORIDA NASN SITE NO. 10270002

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	5.72	5.31	1.46	1.22
1973	6.28[a]	6.13[a]	2.15[a]	1.89[a]
1974	5.65	5.13	1.87	1.45

[a] Indicates insufficient data for statistically valid year.

Table 114. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (INTERNATIONAL AIRPORT, MIAMI)

Date	Precipitation (in.)		Wind speed (mph)		Wind direction (deg)	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
1/18/74	0	0	5.6	2.3	210, 10, 280, 340 220, 80, 80, 90	80
2/16/74	0	0	10.1	9.3	190, 150, 180, 180 210, 210, 230, 240	210
7/10/74	0	0.12	4.6	1.1	190, 340, 350, 330 120, 140, C, C	90

Note: C = Calm

Table 115. RESULTS OF FILTER ANALYSES AT NASN SITE NO. 10270002 IN MIAMI

Date	18 January 1974			16 February 1974			10 July 1974		
TSP (µg/m^3)	90			142			108		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(7+)			(8+)			(8)		
Quartz	1-	<1-50	2	1	<1-250	2	1	<1-150	2
Calcite	6	<1-100	3	6+	<1-200	3	7	<1-150	3
Feldspars	1-			1-			1-		
Hematite	1-	<1-3	0.5	1-			1-		
Mica									
Combustion Products	(1)			(1-)			(1)		
Soot:									
Oil	1-			1-			1-		
Coal	1-						1-		
Glassy fly ash							1-		
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Material	(<1)			(<1)			(<1)		
Pollen	<1			<1					
Spores	<1			<1			<1		
Paper	<1			<1			<1		
Starch							<1		
Misc. plant tissue	<1			<1			<1		
Miscellaneous	(1+)			(1)			(1)		
Iron or steel									
Rubber	1+	<1-150	25	1	<1-200	25	1	<1-150	30

Table 116. COMPOSITE SUMMARY OF FILTER ANALYSES AT NASN SITE NO. 10270002 IN MIAMI

No. of filters	3	
	Quantity, percent	
Components	Average	Range
Minerals	(79)	75-83
Quartz	9	7-10
Calcite	62	60-65
Feldspars	4	4
Hematite	4	4
Mica		
Combustion Products	(9)	7-12
Soot:		
Oil	4	4
Coal	3	2-4
Glassy fly ash	2	1-4
Incinerator fly ash	<1	
Burned wood		
Burned paper	<1	
Magnetite		
Biological Material	(<1)	
Pollen	<1	
Spores	<1	
Paper	<1	
Starch	<1	
Misc. plant tissue	<1	
Miscellaneous	(12)	10-15
Iron or steel	<1	
Rubber	12	10-15

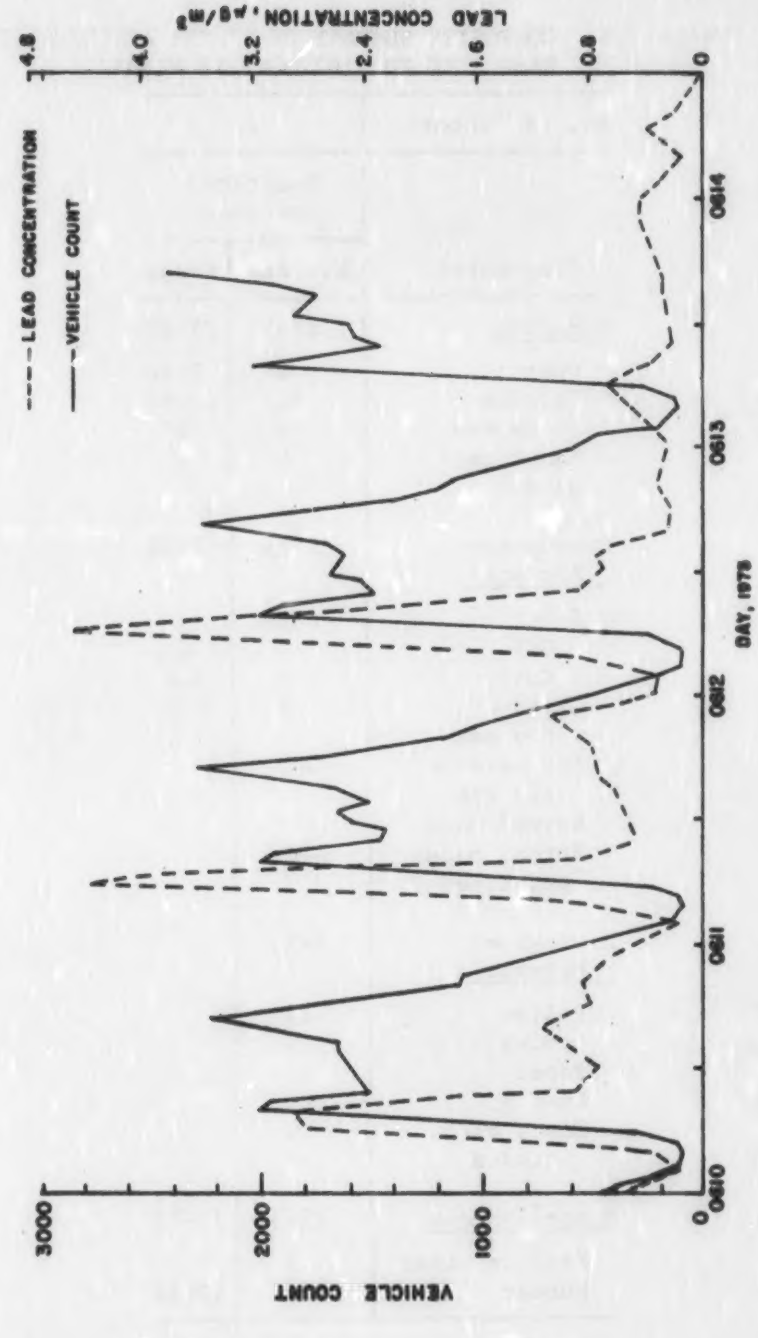

Figure 22. Traffic counts and lead concentrations at Site 10, Miami

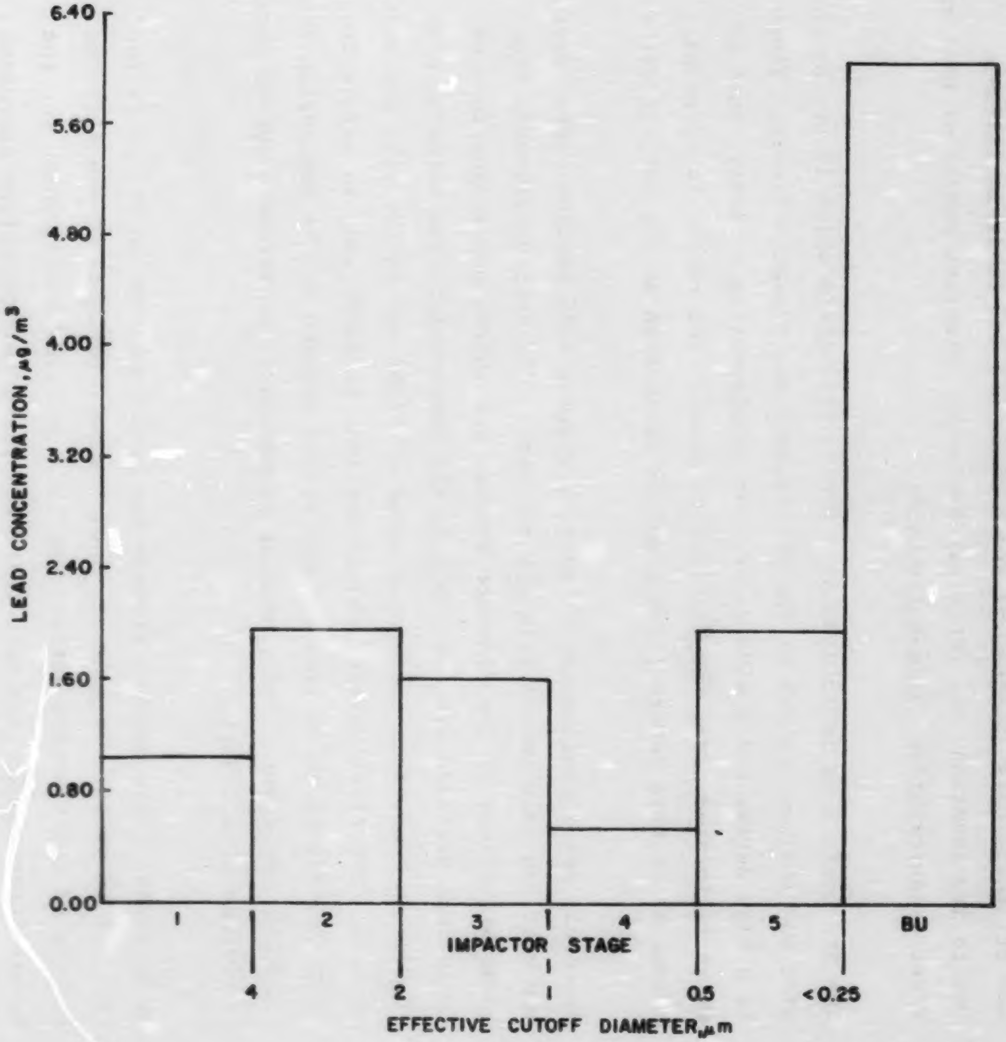

Figure 23. Lead concentration versus particle size at Site 10, Miami

ST. LOUIS

The St. Louis Metropolitan Area is located immediately south of the confluence of the Mississippi and Missouri Rivers. The Metropolitan Area spans the Mississippi River and includes counties in two states - St. Louis and St. Louis City in Missouri and Madison and St. Clair in Illinois Due to its location, St. Louis has become an important center of rail and river transportation and manufacturing.

The St. Louis area is located on a broad, flat plain which is cut by the wide and shallow valleys of the Mississippi and Missouri Rivers. There is a high degree and a wide variety of manufacturing activity, most of which is located along the Mississippi River. The reader is directed to Volume XV of this report for a complete discussion of the subject city.

St. Louis has a continental climate, averaging 4750 heating degree days per year and 36.6 inches rainfall per year. The area experiences frequent migrations of low pressure systems but infrequent stagnations of large high pressure systems. Due to the continental-type climate, poor dispersion conditions frequently occur at night and in the fall and winter seasons. The river valley, though shallow, is sufficient to induce frequent inversions which trap the pollutants emitted by the industries located along the river. Early morning temperature inversions occur on about 65 percent of all days.

An extensive urban renewal program has been conducted in St. Louis for the past 20 years. In general, data are not available to quantify the effects of construction activity on TSP concentrations, except for the Market Street monitoring site (site 20) where concentrations increased 70 $\mu g/m^3$ during 1969 and 1970 while land clearing and construction of the nearby Post Office building was occurring. There is a strong relationship between annual TSP concentrations and the predominant land use surrounding the monitoring sites, The 1974 geometric mean TSP concentrations in the St. Louis Metropolitan Area ranged from 40 $\mu g/m^3$ at a remote site to 50 to 70 $\mu g/m^3$ at the residential sites, 60 to 80 $\mu g/m^3$ at the commercial sites, and generally over 80 $\mu g/m^3$ at the industrial sites. Sixteen of the 33 sampling sites exceeded the annual primary standard and 10 other sites exceeded the annual secondary standard. The 24-hour primary standard was exceeded on 16 sampling days (1.1 percent) and the 24-hour secondary standard on 131 sampling days (8.7 percent). Records show that air quality has been improving since 1969 - sites in St. Louis County showed an average decrease of 21 $\mu g/m^3$, sites in St. Louis City, an average decrease of 72 $\mu g/m^3$, and sites in Madison and St. Clair Counties in Illinois an average decrease of 50 $\mu g/m^3$.

The locations of the six sites that were selected for filter analysis in St. Louis are shown in Figure 24. Table 117 details the pertinent characteristics of these sites, and Table 118 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the micorscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 119. The results of each of the 26 samples submitted for routine analysis are presented in Table 120. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 121. Three filters underwent replicate analyses, and the results of this task are presented in Table 122.

The composite particulate characterization for all filters from St. Louis that underwent routine analysis, presented in Table 123, shows that three quarters of the particulate material is minerals and about one-quarter is composed of combustion products. St. Louis ranks high compared to the other study cities (third out of 14) with respect to the percent mineral content, a somewhat perplexing observation considering the large amount of industry in the area. Although fugitive dust is implicated, the sources of the mineral material are likely varied and the relative contribution of these sources to TSP levels in St. Louis is not clear; the analysts implicate soil and road wear materials in some cases and in other cases they implicate raw material storage piles as the likely source(s). The relatively low levels of rubber found on the filters could seem to contraindicate extensive contributions from vehicular reentrainment. In addition, the microscopists oftentimes observed large amounts of mineral material associated with combustion products. This observation would seem to implicate sources such as steel mills and foundries.

In July 1975 the Aerosol Research Branch of EPA conducted a special ambient air sampling program in St. Louis. This study included both conventional and novel sampling and analysis procedures. Daily TSP levels were monitored with conventional hi-vols while special instrumentation allowed determination of 18 metals at 2-hour intervals, the size distribution of particulates as a function of wind direction, and the corresponding elemental composition of the size fractionated samples. A novel sampling device, known as the streaker,[1] allowed collection of particulate material for subsequent determination of 18 metals with a 2-hour time resolution. This device draws an air sample at a rate of 2 liters per minute through a strip of Nuclepore filter. The sampling head moves at a rate of 2 millimeters per hour which allows the collection of particulate matter for several days of unattended operation. The Nuclepore strip can then be removed for elemental determination of the particulate by proton-induced x-ray emission analysis.[2] This technique is useful for determining the following 18 elements: aluminum, silicon, phosphorus, sulfur, carbon, potassium, calcium, titanium, vanadium, chromium, manganese, iron, nickel, copper, zinc, bromine, strontium, and lead. The use of this powerful analytical technique, combined with the short time resolution of the sampling device, greatly facilitates correlation of the chemical properties of particulate with meteorological parameters.

The ARB studies also included cascade impactors that were controlled by a wind direction sensor. Up to four impactors were operated such that each was operating only when the wind was from a desired direction. For example, each of four impactors could be run only when the wind was from a particular 90 degree sector so that the particle size distribution as a function of the four selected wind directions could be determined. The impactors utilized were low flow rate instruments so that long sampling times (e.g., 1 week) were required. The particulate collected on the impactor stages was also subjected to proton-induced x-ray emission analysis, indicating the elemental composition as a function of particle size.

The results of the study are far too comprehensive for presentation here and will be published separately by EPA. An example of the usefullness of the techniques employed is demonstrated in Figure 25 which shows the temporal variations in the concentration of vanadium, a convenient tracer for residual fuel oil combustion, at the two St. Louis sampling locations included in the ARB program. The Broadway and Hurck site was selected because of its proximity to the heavily industrialized area on the south side of St. Louis and the Municipal Court site was chosen because it is typical of the downtown area. Two large peaks in the vanadium concentration at Broadway and Hurck can be seen late in the day of July 23, 1975. The wind, displayed at the top of the figure, was coming from the 170 to 230 degree sector where the industrial complex is located. At the same time much smaller peaks occur at the Municipal Court site. Whether the increase in vandium concentrations at the downtown site, which is five miles away from the Broadway and Hurck site, is attributable to the same source is impossible to determine.

The vanadium concentration at both sites shows a peak around midday of July 25, 1975. The wind during that period is from the 10 to 15 degree sector, nearly the opposite direction as that observed on July 23. The peak at the Broadway and Hurck site is considerably smaller than on the previously discussed day and the concentration at the Municipal Court site was only slightly lesss. The implications of these observations are twofold: first, vanadium concentration at the Municipal Court site can be increased when the wind is from the 170 to 230 degree sector or the 10 to 50 degree sector but that the increase in concentration is about the same in both cases. Second, the vanadium concentration at the Broadway and Hurck site can also be increased with the wind from either of the two wind directions, but that the increase is much greater when the wind is from the southwesterly direction.

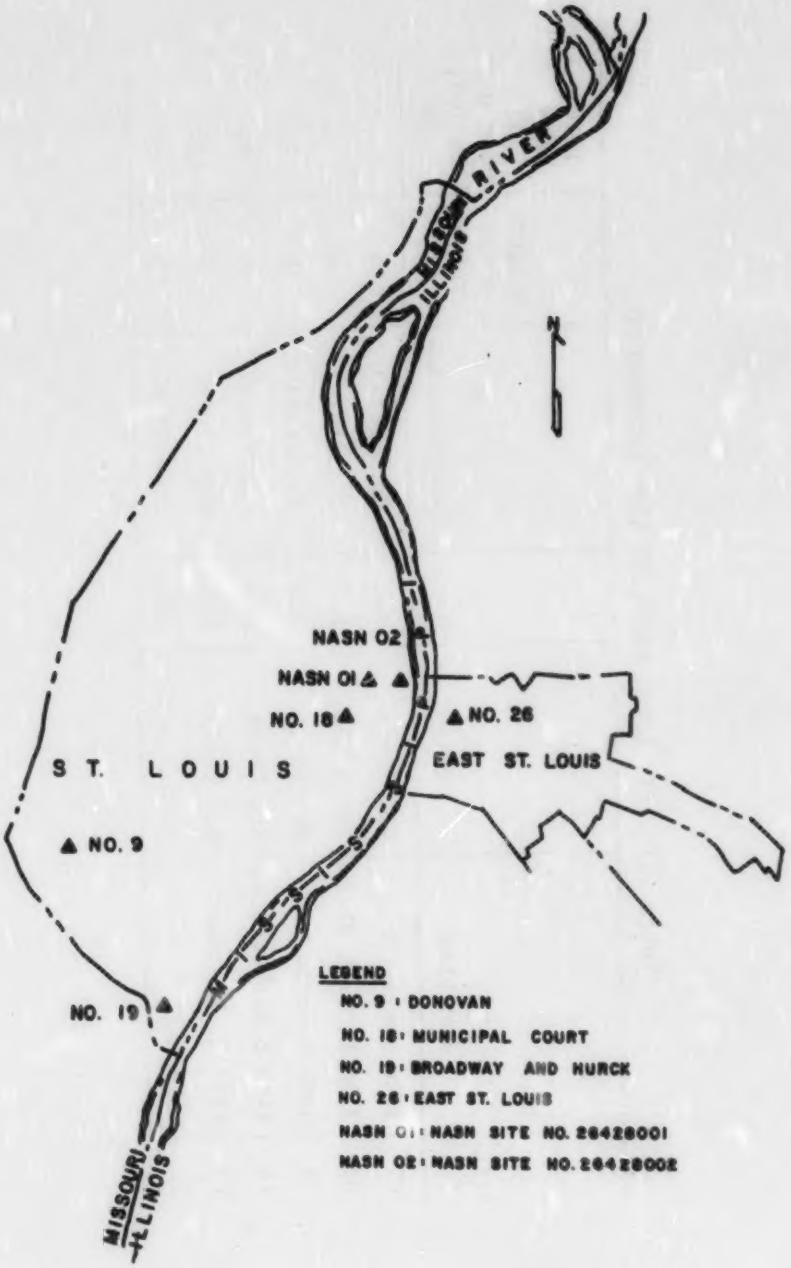
RIVER
MISSOURI
ILLINOIS
N
NASN 02
NASN 01
NO. 18
NO. 26
S T. L O U I S
EAST ST. LOUIS
NO. 9
NO. 19
M I S S I S S I P P I
MISSOURI
ILLINOIS
LEGEND
NO. 9 : DONOVAN
NO. 18 : MUNICIPAL COURT
NO. 19 : BROADWAY AND HURCK
NO. 26 : EAST ST. LOUIS
NASN 01 : NASN SITE NO. 26428001
NASN 02 : NASN SITE NO. 26428002

Figure 24. Location of monitoring sites selected for filter analysis in St. Louis

Table 117. ST. LOUIS SAMPLING SITE INFORMATION

Site No.	Location	City	State	Classification	Height above ground, foot	1974 mean TSP concen-tration, $\mu g/m^3$
01	1720 Market St.	St. Louis	Mo.	Commercial	59	-
02	2155 S. 12th Blvd.	St. Louis	Mo.	Commercial	9	-
9	4408 Donovan St.	St. Louis	Mo.	Residential	30	61
18	14th & Market Sts.	St. Louis	Mo.	Commercial	55	80
19	8227 S. Broadway	St. Louis	Mo.	Industrial	35	126
26	City Hall	E. St. Louis	Ill.	Industrial	50	89

Table 118. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (INTERNATIONAL AIRPORT, ST. LOUIS)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
6/16/74	0	0	11.4	10.9	320, 280, 280, 310 310, 320, 320, 280	310
6/28/74	0	0	1.2	0.0	270, C, C, 90 C, C, C, C	C
7/16/74	0	t	6.6	6.4	50, C, 20, 60 70, 70, 70, 60	60
10/08/74	0	0	4.5	4.4	C, C, C, 220 220, 220, 230, 230	220
11/07/74	0	t	4.2	2.4	C, 250, 280, 280 290, 250, 150, 140	250
11/19/74	t	t	9.4	4.7	150, 170, 130, 140 190, 170, 250, 300	190

Note: C = Calm
t = Trace

Table 119. ANNUAL AVERAGE CONCENTRATION OF SULFATE AND NITRATE IONS AT THE ST. LOUIS, MISSOURI, NASN SITE NO. 264280001 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	16.27	15.01	3.85	3.54
1973	12.36	11.52	3.97	3.68
1974	14.02	12.92	3.75	3.29

Table 120a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN ST. LOUIS AND VICINITY (MUNICIPAL COURT – NO. 18)

Date	16 June 1974			28 June 1974			16 July 1974			8 October 1974			7 November 1974			19 November 1974		
TSP ($\mu g/m^3$)	93			189			99			124			111			70		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(10)	<1-25	5	(9)	1-54	12	(9)	<1-12	3	(7)	1-40	9	(7+)	1-47	5	(3+)	<1-34	7
Quartz	5			4-			1			2+			2+			1+		
Calcite	3+			5-			6			4			4+			2-		
Feldspars	1-						2											
Hematite	1			1-						1-			1-					
Mica																		
Combustion Products	(0+)			(1-)	<1-30	1	(1)	<1-35	1	(2+)	<1-20	1	(2)	<1-29	1	(6+)	<1-90	1
Soot:																		
Oil																		
Coal																		
Soot				1-			1-			2+			1+			6+		
Glassy fly ash													1-					
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(1-)	5-62	22	(1-)	5-50	28	(0+)		
Iron or steel																		
Rubber										1-			1-					

Table 120b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN ST. LOUIS AND VICINITY (S. BROADWAY FIRE HOUSE — NO. 19)

Date	16 June 1974			28 June 1974			16 July 1974			8 October 1974			7 November 1974			19 November 1974		
TSP ($\mu g/m^3$)	131			227			131			258			129			169		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9)	<1-50	3	(6+)	2-39	2	(9)	1-60	6	(8+)	<1-30	2	(7+)	<1-36	3	(7+)	<1-32	5
Quartz	2+			3			3-			1+			3+			4		
Calcite	5			3			6			6+			4			2+		
Feldspars																		
Hematite	1																	
Mica										1-								
Clays	1-																	
Combustion Products	(1)			(3+)	<1-24	1	(1)	<1-6	1	(1+)	<1-150	1	(2+)	<1-22	<1	(2+)	<1-35	1
Soot:																		
Oil	1-																	
Coal																		
Fine soot				3			1			1+			2			2+		
Glassy fly ash				1-														
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Iron or steel																		
Rubber																		

Table 120c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN ST. LOUIS AND VICINITY (EAST ST. LOUIS – No. 26)

Date	16 June 1974			28 June 1974			16 July 1974			8 October 1974			7 November 1974			19 November 1974		
TSP ($\mu g/m^3$)	98			154			112			125			138			77		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(9)	<1-100	5	(9+)	<1-60	3	(8-)	<1-35	5	(5)	<1-60	4	(2)	1-33	5	(8)	1-30	4
Quartz	4			2			2			2-			1-			2-		
Calcite	3+			4			4+			3			2-			6+		
Feldspars																		
Hematite	1+			3			1			1-								
Mica																		
Combustion Products	(1)			(1-)	<1-100	0.5	2	<1-24	1	(5)	<1-60	1	(8)	<1-15	1	(1+)	<1-20	1
Soot:																		
Oil	1-			1-														
Coal																		
Soot							2			4			8			3+		
Glassy fly ash										1								
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(0+)			(0+)			(0+)			(0+)			(0+)			(1-)		
Iron or steel																		
Rubber																		1-

Table 120d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN ST. LOUIS AND VICINITY (DONOVAN STREET — NO. 9)

Date	16 June 1974			28 June 1974			16 July 1974		
TSP ($\mu g/m^3$)	103			104			74		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(9-)	<1-60	3	(6+)	1-18	6	(8)	1-60	7
Quartz	4			4-			4+		
Calcite	3			2+			3		
Feldspars	1-								
Hematite	1						1-		
Mica									
Combustion Products	(1)			(3+)	<1-30	1	(2-)	<1-45	1
Soot:									
Oil									
Coal									
Soot				3+			1		
Glassy fly ash							1-		
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Material	(1-)	<1-70	20	(0+)			(0+)		
Pollen									
Spores									
Paper									
Starch									
Misc. plant tissue	1-								
Miscellaneous	(0+)			(0+)			(0+)		
Iron or steel									
Rubber									

Table 120e. RESULTS OF FILTER ANALYSES FOR SELECTED NASN SITES IN ST. LOUIS AND VICINITY (SITE NOS. 264280001 AND 26480002)

Site	NASN Site – No. 264280001									NASN Site – No. 264280002					
Date	16 June 1974			7 November 1974			19 November 1974			7 November 1974			19 November 1974		
TSP (μg/m^3)	58			163			68			156			119		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8+)			(6)			(9)	<1-47	7	(6)			(7-)		
Quartz	4	<1-60	3	2	<1-100	5	2			1+	<1-80	2	2	<1-100	5
Calcite	4	<1-60	3	4-	<1-100	5	7			3+	<1-60	2	3+	<1-100	5
Feldspars										1-					
Hematite	1-	<1-20	0.5	1	<1-	0.5				1	<1-20	0.5	1	<1-100	0.5
Mica															
Combustion Products	(1-)			(2)			(1)			(1+)			(1)		
Soot:															
Oil	1-	<1-80	0.5	1	<1-120	0.5				1	<1-100	0.5	1-		
Coal													1-		
Glassy fly ash				1	<1-30	10									
Incinerator fly ash															
Burned wood															
Burned paper															
Magnetite															
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(1)			(1)			(0+)			(2+)			(2)		
Iron or steel															
Rubber	1	<1-120	30	1	<1-120	6				2+	<1-180	30	2	<1-150	30

Table 121. **COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN ST. LOUIS AND VICINITY**

Site	Municipal Court – No. 18		Fire House (Broad) – No. 19		E. St. Louis No. 26		Donovan No. 9		NASN No. 26428001		NASN No. 26428002	
No. of filters	6		6		6		3		3		2	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(76)	35-99	(80)	65-92	(69)	21-93	(77)	63-86	(83)	70-91	(65)	62-67
Quartz	27	12-50	29	15-42	19	4-40	41	36-45	27	20-40	18	15-20
Calcite	40	18-60	45	25-61	38	16-65	29	24-32	48	37-68	35	35
Feldspars	4	0-20	<1	0-2	1	0-3	1	0-4	2	0-3	3	2-4
Hematite	5	0-10	5	1-10	11	1-30	6	3-12	6	3-10	9	8-10
Mica												
Clays			1	0-5								
Combustion Products	(21)	1-65	(19)	8-34	(30)	7-79	(21)	9-35	(11)	5-20	(12)	11-13
Soot:												
Oil	<1	0-1	1	0-4	1	0-5	1	0-3	5	0-10	7	4-10
Coal	<1		<1	0-2	1	0-2	1	0-2	1	0-2	2	<1-4
Fine soot	[illegible]	0-65	17	0-30	26	0-79	15	0-34	2	0-8		
Glassy fly ash	1	0-4	1	0-4	2	0-10	3	1-6	3	0-8	2	2-3
Incinerator fly ash	<1		<1		<1		1	0-2			1	0-1
Burned wood	<1						<1				<1	
Burned paper	<1				<1		<1				<1	
Magnetite												
Biological Material	(<1)		(<1)		(<1)	0-1	(2)	<1-5	(<1)		(1)	0-2
Pollen	<1		<1		<1		<1		<1		<1	
Spores	<1		<1		<1		<1		<1		<1	
Paper	<1		<1		<1		<1		<1		<1	
Starch	<1		<1		<1		<1		<1		<1	0-1
Misc. plant tissue	<1		<1		<1	0-1	2	tr-5	<1		<1	0-1
Miscellaneous	(3)	0-7	(1)	0-2	(1)	0-4	(<1)		(7)	0-10	(22)	20-25
Iron or steel	<1	0-1	<1		<1		<1		<1		<1	
Rubber	3	0-7	1	0-2	1	0-4	<1		7	0-10	22	20-25

Table 122. RESULTS OF REPLICATE ANALYSES OF ST. LOUIS FILTERS

Site	East St. Louis – No. 26					
Date	28 June 1974		16 July 1974		7 November 1974	
TSP ($\mu g/m^3$)	154		112		138	
Laboratory	A	B	A	B	A	B
Analyses	1	1	1	1	1	1
Components						
Minerals	(93)	(48)	(77)	(23)	(21)	(43)
Quartz	20		20		4	
Calcite	40		45		16	
Feldspars	3					
Hematite	30		12		1	
Mica						
Combustion Products	(7)	(52)	(21)	(77)	(79)	(57)
Soot:						
Oil	5	4		37		9
Coal	1					
Soot			21		79	
Glassy fly ash	1	48		40	tr	48
Incinerator fly ash	<1					
Burned wood						
Burned paper						
Magnetite						
Biological Material	(<1)	(<1)	(1)	(<1)	(<1)	(<1)
Pollen						
Spores	<1		tr			
Paper			tr			
Starch						
Misc. plant tissue	<1		1			
Miscellaneous	(<1)	(<1)	(<1)	(<1)	(<1)	(<1)
Iron or steel	<1		<1			
Rubber						

Table 123. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN ST. LOUIS

No. of filters	26		
	Quantity, percent		
Components	Average		Range
Minerals		(75)	21-99
Quartz		26	4-50
Calcite		40	16-68
Feldspars		2	0-20
Hematite		7	0-30
Mica			
Other		<1	0-5
Combustion products		(21)	1-79
Soot:			
Oil		2	0-5
Coal		<1	0-2
Misc. soot		16	0-79
Glassy fly ash		2	0-10
Incinerator fly ash		<1	0-2
Burned wood		<1	
Burned paper		<1	
Magnetite			
Carbon black			
Other			
Biological material		(<1)	0-5
Pollen		<1	
Spores		<1	
Paper		<1	
Starch		<1	
Misc. plant tissue		<1	0-5
Leaf trichomer			
Miscellaneous	15	(4)	0-10
Iron or steel		<1	
Rubber	15	4	0-10
Other			

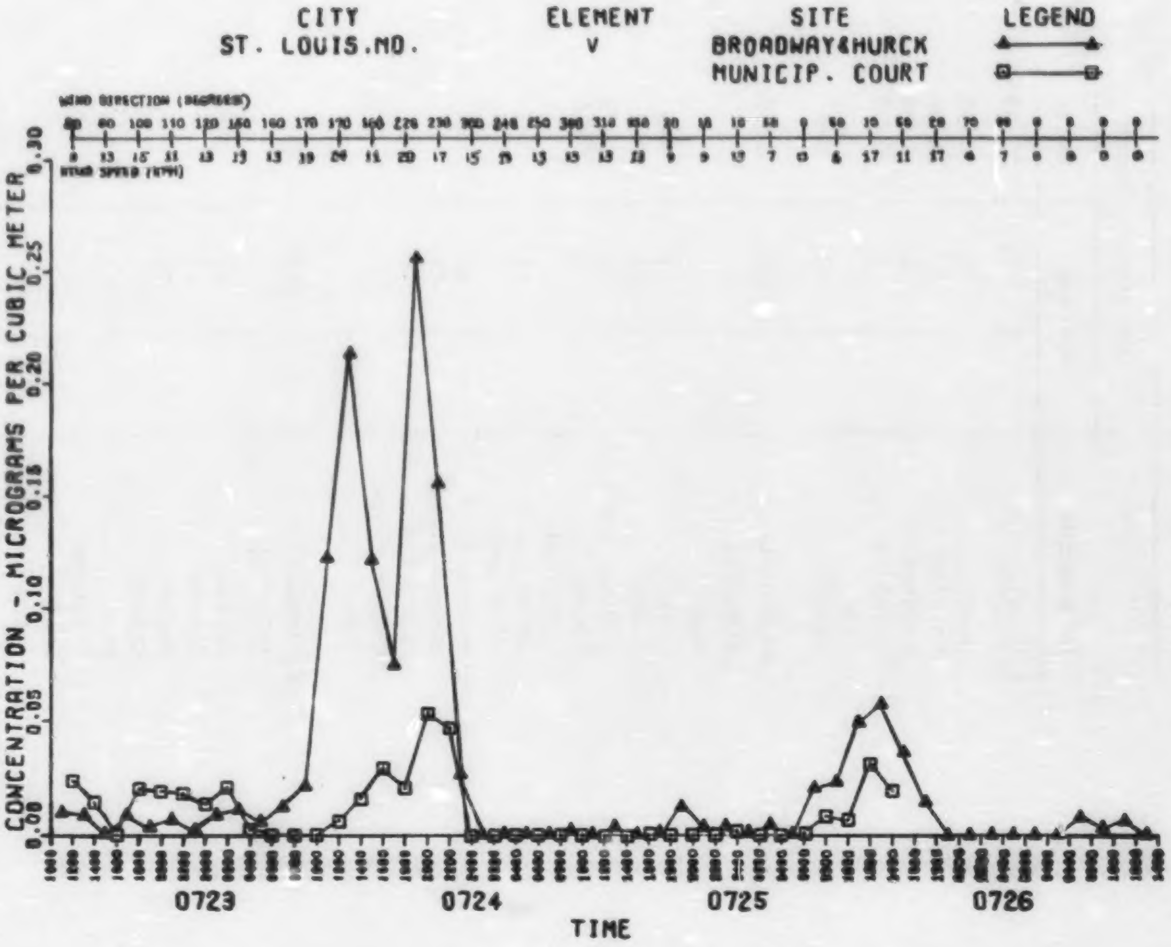

Figure 25. Temporal variation in the concentration of vanadium at two St. Louis sites

PROVIDENCE

Providence, Rhode Island, located in the northeastern portion of the United States, is an example of an area which is meeting the air quality standards for particulates and has never had much of a problem except for a few center city monitoring sites. Providence is included in the study because it is a coastal city, receiving frequent rain, with a small amount of industrial activity but large space heating requirements. The reader is directed to Volume XVI of this report for a complete discussion of the subject city.

The general pattern of particulate concentrations is concentric about the metropolitan area, with most of the sites at or below the annual secondary standard of 60 $\mu g/m^3$. Out of the 21 monitors in the State in 1974, only one site (number 42 on Dyer Street in Providence) exceeded the national annual primary standard of 75 $\mu g/m^3$ while four sites exceeded the annual secondary standard. The 24-hour secondary standard was exceeded eight times, at a total of six stations, out of 966 total observations. All of the violations of the standards occurred at sampling sites in the center-city area of metropolitan Providence.

The locations of the five sites that were selected for filter analysis in Providence are shown in Figure 26. Table 124 details the pertinent characteristics of these sites, and Table 125 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table 126. The results for each of the 25 filters submitted for routine analysis are presented in Table 127. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table 128. Nine filters underwent replicate analyses, and the results of this task are presented in Table 129.

The composite particulate characterization for all filters from Providence that underwent routine analysis, presented in Table 130, shows that most of the TSP is composed of minerals. The average percent minerals reported, however, is not atypical in terms of the other cities studied, with Providence ranked eighth out of the 14 cities. The amount of combustion products is also quite typical, with Providence ranked ninth highest in that category. The predominant type of combustion product identified was oil soot, an expected result in view of the predominance of oil as a fuel in the area. In fact, the identification of coal soot and fly ash, although in very small amounts, was somewhat surprising because coal is not believed to be utilized at all in the Providence area.

The average percent rubber reported is high, with only one other city included in the study exceeding Providence. The composite average of 16 percent rubber is not the result of a few isolated observations; indeed, 23 of the 25 filters analyzed were reported to have rubber on them. The highest observed percent rubber content of any sample was 35 percent at the Westminster Street site which is located 100 feet above street level. The Dyer Street site, which had the highest 1974 TSP levels in the Providence AQCR, also had the highest average rubber content. This finding is strongly supportive of the belief that the high TSP levels at Dyer Street are adversely affected by the proximity of the site to Interstate 195.

Three of the filters from Providence were also submitted for determination of particle size as a function of particle type, as shown in Figures 27 through 29. One of these samples was also selected for detailed physical analysis, and the results are presented in Table 131.

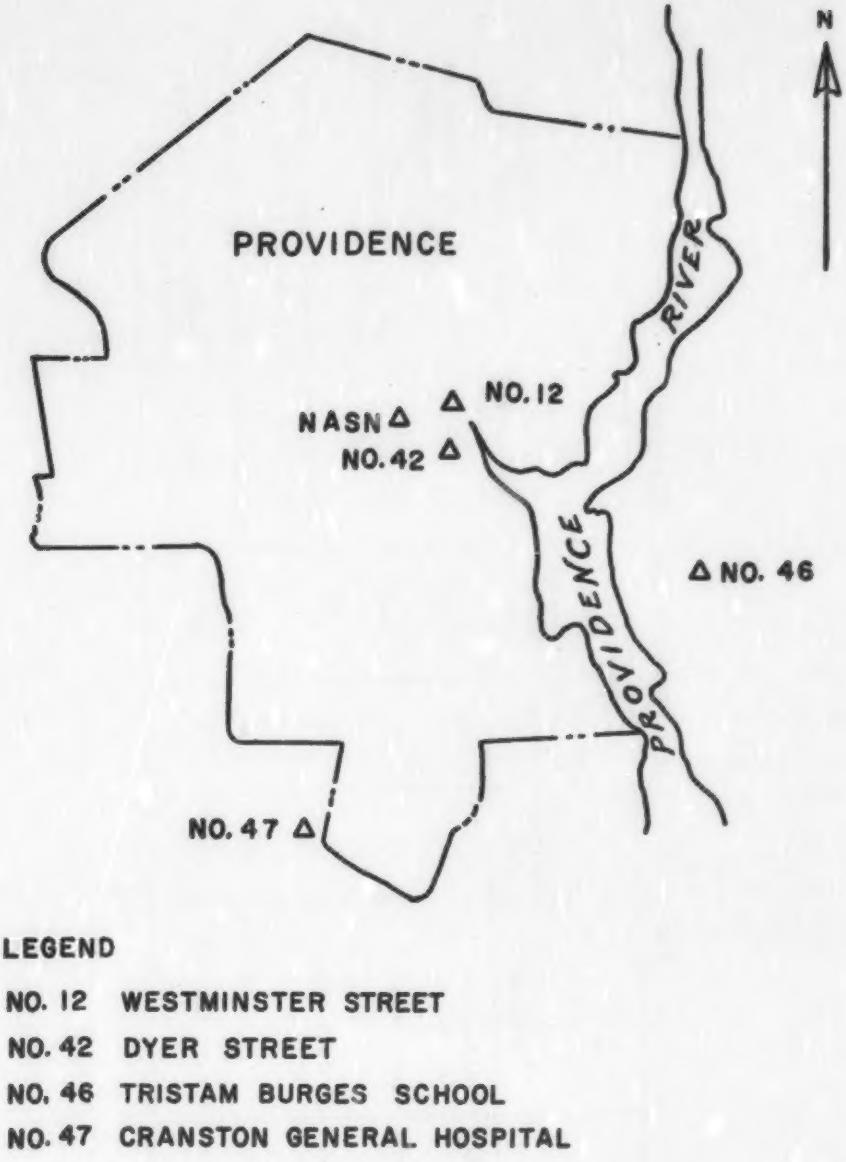
N
PROVIDENCE
PROVIDENCE RIVER
NASN
NO. 12
NO. 42
NO. 46
NO. 47
LEGEND
NO. 12 WESTMINSTER STREET
NO. 42 DYER STREET
NO. 46 TRISTAM BURGES SCHOOL
NO. 47 CRANSTON GENERAL HOSPITAL

Figure 26. Providence TSP monitoring sites selected for filter analyses

Table 124. SAMPLING SITE CHARACTERISTICS

DAPC code	Town	Address	Height, feet	24-hour second highest value, $\mu g/m^3$	1974 geometric mean TSP	Site characteristic	Major influences on air quality levels
12	Providence	Westminster Street	100	134	68	CBD	Space heating, screened by taller buildings
42	Providence	Dyer Street	15	173	88	CBD	Beside expressway, near power plant
46	East Providence	Tristam Burges School	30	140	61	Residential	General urban activity, unpaved streets
47	Cranston	General Hospital	50	98	43	Residential	Residential area activity
52	Providence	Police Station	45		66	CBD	General urban activity, near expressway

Table 125. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (THEO. FRANCIS GREEN STATE AIRPORT, PROVIDENCE)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
3/24/74	0.01	0.06	11.7	7.5	70, 320, 330, 210 250, 330, 300, 320	300
8/15/74	0	0	9.4	5.7	360, 350, 360, 30 20, 160, 300, 360	360
9/20/74	0	t	7.5	5.5	180, 210, 180, 170 220, 190, 190, 350	200
10/14/74	0	t	9.6	7.5	C, 340, 300, 170 170, 170, 180, 190	180
10/26/74	0	0.10	9.5	7.7	290, 320, 340, 330 310, 300, 230, 250	300
11/01/74	0	0.49	9.2	8.5	200, 230, 230, 220 260, 250, 270, 270	240
11/19/74	0	0	6.8	5.5	280, 320, 230, 350 310, 290, 260, 250	290
12/19/74	0.02	0	9.1	8.6	270, 280, 270, 250 260, 210, C, 250	260

Note: C = Calm
t = Trace

Table 126. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE PROVIDENCE, RHODE ISLAND, NASN SITE NO. 410300001 (μg/m^3)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	11.11	10.14	1.50	1.17
1973	10.83[a]	9.77[a]	2.35[a]	1.91[a]
1974	9.98[a]	8.87[a]	2.92[a]	2.35[a]

[a] Indicates insufficient data for statistically valid year.

Table 127a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PROVIDENCE AND VICINITY (WESTMINSTER STREET — NO. 12)

Date	15 August 1974			20 September 1974			14 October 1974			1 November 1974			19 November 1974			19 December 1974		
TSP ($\mu g/m^3$)	63			72			58			96			91			74		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(9-)	<1-32	9	(8)	<1-90	16	(5)	1-55	33	(3)	<1-80	15	(7)	1-65	12	(4)	1-50	12
Quartz	5-			6+			2+			2-			5+			3		
Calcite	3			1-			1			1						1-		
Feldspars				1-			1-						1-			1		
Hematite				1-			1			1-			1-					
Mica	1																	
Combustion Products	(1)	<1-21	1	(1-)			(2)	<1-32	15	(6)	<1-90	8	(1)	<1-35	3	(2+)	<1-35	<1
Soot:																		
Oil							2			(6)			1					
Coal	1-																	
Fine soot																2+		
Glassy fly ash																		
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(1-)			(1+)	5-75	45	(3)	12-270	36	(1)	10-120	39	(2)	6-105	35	(3+)		15
Iron or steel																		
Rubber	1-			1+			3			1			2			3+		

Table 127b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PROVIDENCE AND VICINITY (TRISTAM BURGES SCHOOL — NO. 46)

Date	15 August 1974			20 September 1974			14 October 1974			1 November 1974			19 November 1974			19 December 1974		
TSP ($\mu g/m^3$)	48			66			43			74			68			44		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8+)	<1-50	15	(9)	<1-45	9	(6+)	1-95	15	(8)	<1-30	10	(4-)	<1-47	6	(7+)	1-80	18
Quartz	6			7			4+			7			2+			4+		
Calcite	2		1-2				1									1-		
Feldspars																1-		
Hematite	1-			1			1			1-			1			2		
Mica				1-														
Combustion Products	(1)	<1-10	<1	(1-)			(1)	<1-60	2	(2)	<1-110	4	(6+)	<1-54	11	(1-)		
Soot:																		
Oil							(1)			1			(6+)					
Coal																		
Soot										1-						1-		
Glassy fly ash										1-								
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Very fine carbon black	(1)																	
Biological Material	(0+)			(0+)			(1-)	15-200		(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue							1-											
Miscellaneous	(1-)	5-150		(0+)			(2)	5-80	50	(0+)			(0+)			(2)	7-120	21
Iron or steel																		
Rubber	1-						(2)									2		

Table 127c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PROVIDENCE AND VICINITY (CRANSTON GENERAL HOSPITAL — NO. 47)

Date	15 August 1974			20 September 1974			14 October 1974			1 November 1974			19 November 1974			19 December 1974		
TSP ($\mu g/m^3$)	44			54			37			89			89			52		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(7+)	<1-80	7	(7)	<1-80		(5)	1-80	9	(3)	<1-35	9	(8+)	<1-60	7	(7-)		
Quartz	2			5			3-			1			7			2+		
Calcite	1			1			1									1		
Feldspars	2												1			1+		
Hematite	1			1			1-			2			1-			1+		
Mica	1+						1+											
Combustion Products	(2)	<1-115		(2)	<1-25	1	(2)	<1-40	2	(7)	<1-65	5	(1+)	<1-150	9	(1-)	<1-20	18
Soot:																		
Oil	} 1			2-			2-			3								
Coal										1								
Very fine	1												1+			1-		
Glassy fly ash										3								
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(1-)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue				1-														
Miscellaneous	(1-)			(1)	-150		(3)	10-60	50	(0+)			(0+)			(3)	3-90	23
Iron or steel																		
Rubber	1-			1			3									3		

Table 127d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PROVIDENCE AND VICINITY (DYER STREET — NO. 42)

Date	14 October 1974			1 November 1974			19 November 1974		
TSP ($\mu g/m^3$)	61			110			98		
Components	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm	Quantity, tenths	Size range, µm	Avg. size, µm
Minerals	(5)	1-92	18	(8-)	<1-80	12	(3-)	2-60	12
Quartz	3+			6			2-		
Calcite							1		
Feldspars				1-					
Hematite	1			1					
Mica									
Combustion Products	(1+)	<1-31	20	(1)	<1-15	3	(4)	<1-73	7
Soot:									
Oil							4		
Coal									
Soot and spheres	1+		20						
Glassy fly ash				1-					
Incinerator fly ash									
Burned wood									
Burned paper									
Magnetite									
Biological Material	(0+)			(0+)			(0+)		
Pollen									
Spores									
Paper									
Starch									
Misc. plant tissue									
Miscellaneous	(3+)	30-225	45	(2-)	8-75	18	(3)	11-69	26
Iron or steel									
Rubber	3			2-			3		

Table 127e. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN PROVIDENCE AND VICINITY (NASN SITE NO. 410300001)

Date	26 March 1974			15 August 1974			20 September 1974			26 October 1974		
TSP (μg/m^3)	8[illegible]			67			NA^a			34		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8)			(9-)	<1-125	10	(9)	3-66	26	(6)	1-30	
Quartz	6	2-150	40	6+			4			1+		
Calcite	1-	5-50	30							3		
Feldspars	1-	2-75	30	1+			4+					
Hematite	1	1-50	10				1-			1+		
Mica												
Hydrated Fe oxides				1								
Combustion Products	(1+)			(1-)	8-35		(0+)			(1)	1-32	2
Soot:												
Oil	1	1-60	30									
Coal	1-	2-50	20									
Soot										1		
Glassy fly ash												
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(0+)			(0+)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(1-)			(1-)	3-62	9	(1)	6-70	30	(3)	2-33	40
Iron or steel												
Rubber	1-			1-			1			3		

Table 128. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN PROVIDENCE AND VICINITY

Site	Site No. 12		Site No. 46		Site No. 47		Site No. 42		NASN Site	
No. of filters	6		6		6		3		4	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(60)	31-87	(72)	37-92	(63)	31-85	(38)	28-53	(79)	61-89
Quartz	39	16-65	51	24-71	34	11-71	27	20-35	44	15-63
Calcite	11	2-31	7	2-20	6	2-10	2	2-3	9	0-30
Feldspars	2	0-6	2	0-5	7	0-20	5	2-6	16	0-45
Hematite	6	0-10	10	5-20	10	4-18	3	tr-9	7	0-15
Mica	2	0-10	2	<1-5	6	0-15	<1		1	0-2
Other									2	0-9
Combustion Products	(21)	4-60	(19)	6-63	(24)	5-68	(38)	36-40	(9)	2-15
Soot										
Oil	14	0-59	14	0-63	11	0-30	15	8-25	4	0-10
Coal	1	0-5			2	0-13	6	0-15	1	0-5
Fine soot	5	0-27	2	0-5	6	0-13	4	0-8	3	0-10
Glassy fly ash	1	0-3	1	0-5	5	0-29	2	0-6	1	0-2
Incinerator fly ash							11	10-16		
Burned wood										
Burned paper										
Magnetite										
Carbon black			2	0-10						
Biological Material	(<1)	0-1	(1)	0-5	(1)	<1-4	(1)	1-2	(<1)	
Pollen	<1		<1		<1		<1		<1	
Spores	<1		<1		<1		<1			
Paper	<1		<1	0-1	<1		<1	0-2	<1	
Starch	<1		<1		<1				<1	
Misc. plant tissue	<1	0-1	1	0-4	1	0-4	<1	tr-1	<1	
Miscellaneous	(19)	4-35	(8)	0-18	(12)	<1-28	(23)	10-30	(12)	5-28
Iron or steel	<1		<1		<1		<1		<1	
Rubber	19	4-35	8	0-18	12	0-28	23	10-30	12	5-28

Table 129. RESULTS OF REPLICATE ANALYSES OF PROVIDENCE FILTERS

Site	Dyer Street – No. 42						Westminster Street – No. 12								Tristam Burges School No. 46					Cranston Gen. Hospital – No. 47	
Date	14 October 1974		1 November 1974		19 November 1974		15 August 1974				1 November 1974		19 November 1974		20 September 1974		1 November 1974			20 September 1974	
TSP ($\mu g/m^3$)	61		110		98		63				96		91		66		74			54	
Laboratory	A	A	A	A	A	A	A	A	B	B	A	A	A	A	A	B	A	A	B	A	A
Analyses	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	1	1	2	1	1	2
Components																					
Minerals	(48)	(32)	(76)	(53)	(27)	(28)	(87)	(46)	(5)	(66)	(31)	(22)	(68)	(10)	(92)	(10)	(80)	(14)	(5)	(69)	(23)
Quartz	35	27	59	35	16	20	46	15			16	5	54	4	70		71	8		50	14
Calcite		2	1	3	8	2	31	8			9	1	2	1	3		2	3		8	2
Feldspars		2	6	6		6		16				5	6	4	2			2		2	7
Hematite	12	1	10	9	1	tr		5			6	10	5	<1	12		6	tr		9	tr
Mica	1	tr		tr	2	tr	10	2				tr	1	<1	5		1	1			tr
Coal												1		<1							
Combustion Products	(15)	(37)	(8)	(36)	(42)	(40)	(8)	(26)	(95)	(27)	(60)	(56)	(10)	(50)	(4)	(90)	(18)	(49)	(95)	(18)	(38)
Soot:																					
Oil		8		12	42	25		8	12	4	59	40	9	25	3		8	12	25	17	3
Coal		15				2	5	12				2		5							10
Fine soot	15		3	8		3								15			5	3			
Glassy fly ash			5	6			3		83	23	1	10	<1		<1	90	5	7	70	1	2
Incinerator fly ash		14		10		10		6				4		5				25			23
Burned wood																		2			
Burned paper																					
Magnetite						tr															
Biological Material	(3)	(1)	(<1)	(1)	(<1)	(2)	(1)	(3)	(<1)	(7)	(<1)	(8)	(1)	(5)	(1)	(<1)	(<1)	(12)	(<1)	(4)	(18)
Pollen	<1	tr		tr		tr		3				1		2			tr	2			1
Spores	<1	tr	<1	tr		tr	<1	tr			<1	<1	tr	tr	<1		<1	8		tr	
Paper	<1	tr				2	<1	<1			<1	1		1	<1		<1	1		<1	3
Starch			<1								<1	5	tr	tr			tr				
Misc. plant tissue	2	1	<1	1		tr	tr	tr				1	1	<1	1		<1			4	14
Other	1			tr										<1				1			
Miscellaneous	(33)	(30)	(16)	(10)	(31)	(30)	(4)	(25)	(<1)	(<1)	(9)	(15)	(21)	(35)	(3)	(<1)	(2)	(25)	(<1)	(9)	(21)
Iron or steel	tr		tr		tr								tr							<1	
Rubber	33	30	16	10	31	30	4	25			9	15	21	35	3		2	25		9	21
Asphalt												tr									

Table 130. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN PROVIDENCE

No. of filters	25	
	Quantity, percent	
Components	Average	Range
Minerals	(64)	28-92
Quartz	39	11-71
Calcite	7	0-31
Feldspar	7	0-45
Hematite	8	0-18
Mica	3	0-15
Other[a]		
Combustion products	(22)	2-68
Soot:		
Oil	12	0-63
Coal	2	0-15
Misc. soot	4	0-27
Glassy fly ash	2	0-29
Incinerator fly ash	1	0-14
Burned wood		
Burned paper		
Magnetite		
Carbon black	1	0-10
Other[a]		
Biological Material	(1)	0-5
Pollen	<1	
Spores	<1	
Paper	<1	0-2
Starch	<1	
Misc. plant tissue	1	0-4
Leaf trichomer		
Miscellaneous	(13)	0-35
Iron or steel	<1	
Rubber	13	0-35
Other		

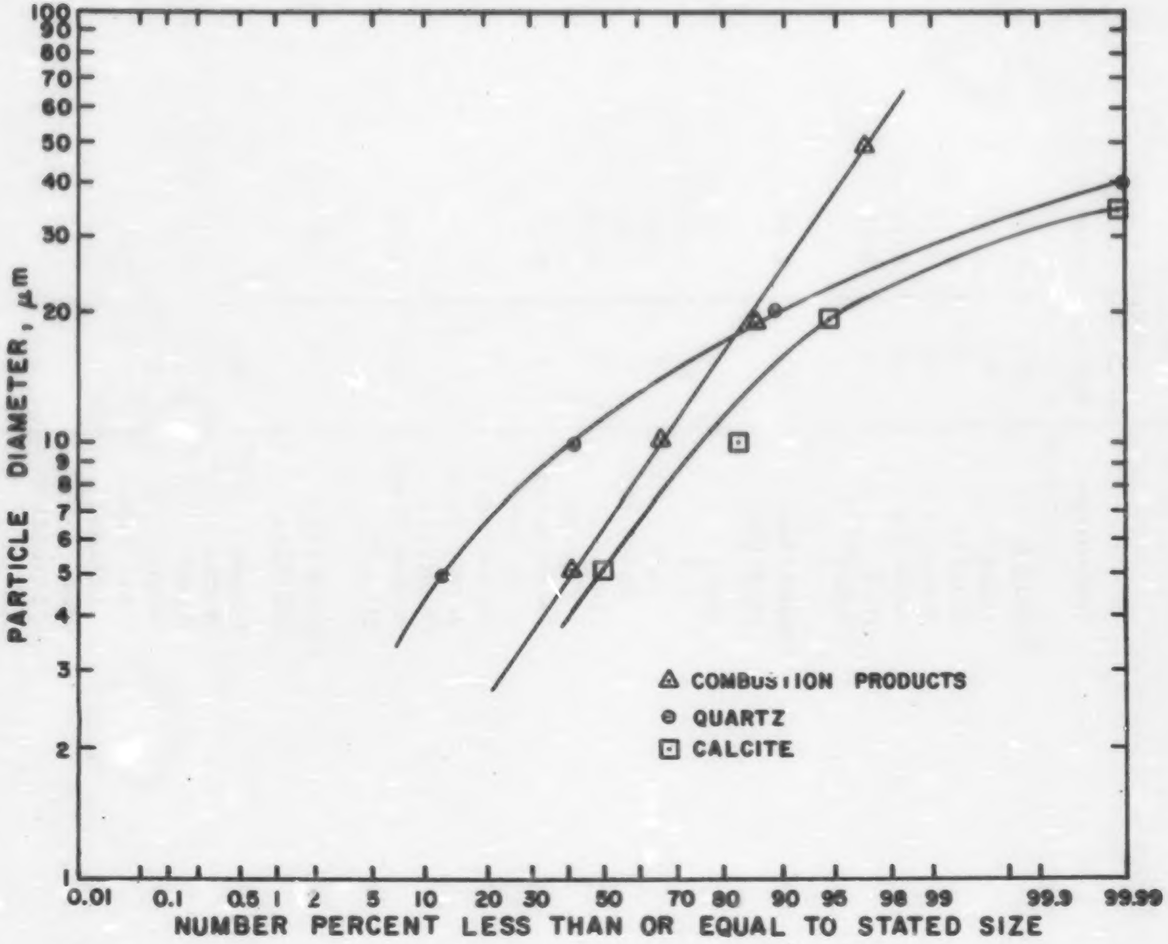

Figure 27. Cumulative particle size distributions for three particle types, Westminster Street site, Providence, August 15, 1974

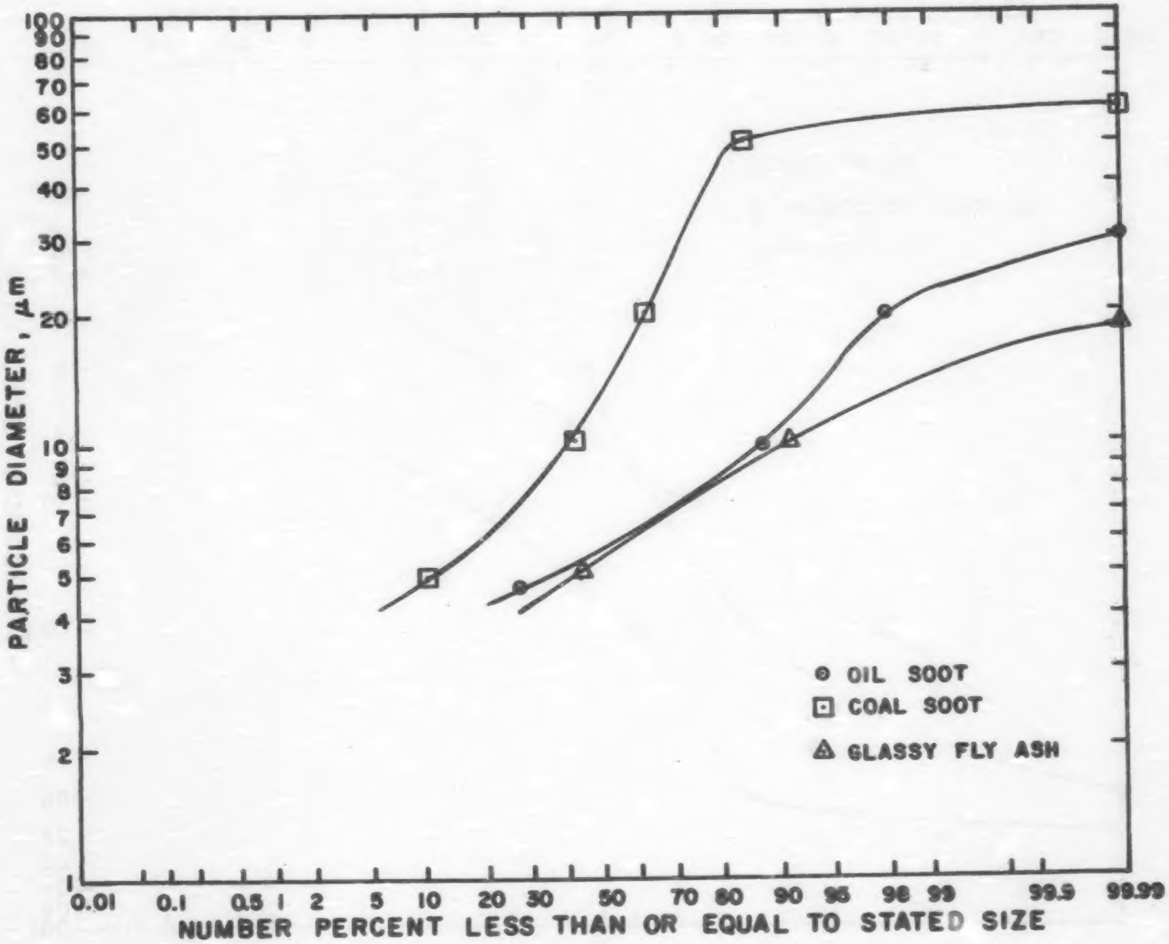

Figure 28. Cumulative particle size distributions for three particle types, Tristam Burges School, Providence, September 20, 1974

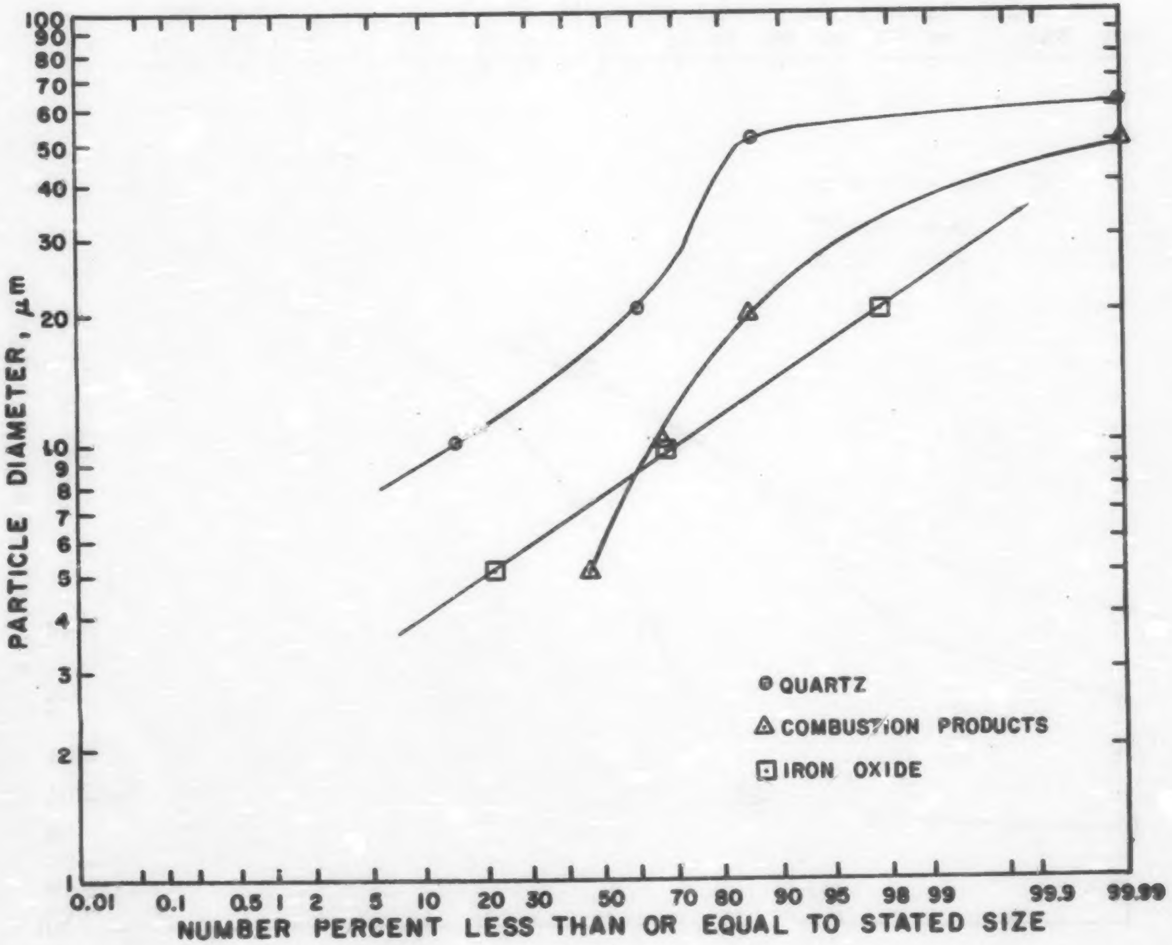

Figure 29. Cumulative particle size distributions for three particle types, Dyer Street, Providence, November 19, 1974

Table 131. DETAILED PHYSICAL ANALYSIS: DYER STREET, PROVIDENCE, NOVEMBER 19, 1974

A. Quartz confirmed by dispersion staining and (-) uniaxial interference figure. EDXRA shows only silicon and trace of iron (from hematite).

B. Calcite confirmed by EDXRA - shows only calcium.

C. Oil soot confirmed (as far as possible, due to small particle size and variability of fly ash due to operating conditions) by brittleness, morphology and especially EDXRA analysis showing: aluminum, silicon (both from clay - feldspar impurities); calcium, sulfur, chlorine (these as normal constituents of oil soots); iron and vanadium (normal constituents of oils). The major constituent was carbon.

D. Rubber was confirmed by its elastomeric nature, surface appearance and EDXRA spectrum showing mostly carbon with minor amounts of calcium, aluminum, silicon (all probably from road wear products), sulfur, chlorine, iron, titanium, and zinc.

SECTION VII

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